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ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the February Number, p. 53.*)

(PLATE IX.)

A DEVELOPMENTAL sequence of *Membraniporellæ* showing progressive subordination of the ribbed front wall to a solid secondary front wall can be traced fairly directly from *Membraniporella pustulosa*, Bryd.,[1] which is prevalent in the zone of *M. cor-anguinum* and the *Uintacrinus* band and seems to die out in the zone of *Marsupites*. In the zone (restricted) of *A. quadratus* it is succeeded by

Membraniporella thoraciformis, sp. nov. (Pl. IX, Figs. 1–3.)

Zoarium unilaminate, incrusting.

Zoœcia of medium size, but very variable, average length from ·55 to ·7 mm.; the primary zoœcium is a simple form with a semicircular aperture surrounded by a thickened rim bearing a blunt median denticle, and an arched front wall arising just within slightly arched side walls and pierced by seven or eight pairs of short narrow slits; a prominent tubular secondary aperture is formed by general uprising of the margin of the aperture as in *M. pustulosa*, but the cavities which in that form are left on either side of the marginal denticle are closed in this species; at the same time a thin horizontal lamina extends from the lower side of the lower lip of the aperture some way downwards over the front wall, and this lamina and the tubular aperture combine to resemble very closely a throat and breast; at the same time the side walls swell and more or less completely coalesce.

Oœcia.—The immature and circumferential zoœcia have small, very globose oœcia, with an appearance of being perched on the margin of the aperture; as the secondary aperture develops it embraces the greater part of the oœcia, and its full development renders them very inconspicuous.

Avicularia accessory, small, bluntly mandibular, with arrowhead-shaped apertures crossed by a slender bar, placed at the lower side of the secondary aperture and generally leaning up against it in a slightly forward direction; they are very erratic in occurrence, as the figures show. Although this species appears to be most prevalent

[1] Geol. Mag., 1910, p. 483, Pl. XXXVI, Fig. 9.

at the top of the (restricted) zone of *A. quadratus*, it is very doubtful if it persists into the zone of *B. mucronata*. It seems to be succeeded in the base of the latter zone by the following species.

MEMBRANIPORELLA MANONIA, sp. nov. (Pl. IX, Figs. 4–7.)

Zoarium free or incrusting, multilaminate when free, generally multilaminate but occasionally unilaminate when incrusting.

Zoœcia of medium size but very variable, average length from ·55 to ·7 mm.: the primary zoœcia have semicircular apertures with a denticle on the lower lip and arched front walls arising from just within arched side walls and pierced by four or five pairs of long wide slits: the secondary aperture is formed as in the preceding species, but is rather contracted and keeps much lower, occupying a more or less central position in a gentle eminence, in the sides of which there are generally two but occasionally one or three rather smaller holes of irregular shape; the encroachment on the front wall by a thin horizontal lamina, which in the preceding species takes place only at the upper end, takes place in this species all round the front wall until in the older parts of the zoœcium only a small hole of irregular shape is left, at the bottom of which the front wall can hardly, if at all, be seen; the side walls coalesce and swell up to the general level, and the zoarium becomes an undulating expanse devoid of features except scattered holes, and resembling the surface of a Calcisponge such as *Manon*.

Oœcia.—There are practically no suggestions of oœcia among the peripheral zoœcia, and it is therefore improbable that they are represented by any of the holes which form the features of the mature zoœcia.

Avicularia are probably the origin of the holes accessory to the secondary aperture, although no ordinary avicularian structure is preserved in them; these avicularian holes occur usually in pairs beside the aperture, but one may be suppressed or a third added above the aperture; they lead to deep chambers. This species occurs very consistently in the lower part of the zone of *B. mucronata*, to which it seems a very reliable guide, in Hants and the Isle of Wight: no trace of it has yet been observed in any chalk that could be attributed to the zone of *A. quadratus*. All the figures represent segments of circular patches selected to show the passage from young to mature zoœcia.

MEMBRANIPORELLA TRANSLIGATA, sp. nov. (Pl. IX, Figs. 8, 9.)

Zoarium unilaminate, incrusting.

Zoœcia small, average length ·5 to ·6 mm.: the primary zoœcium was apparently of the same general type as in the two preceding species, the semicircular aperture having a very thick denticulated lower lip, from the lower side of which a broad process descends to a very short front wall arising rather deep within wide common side walls and pierced by three or four pairs of fairly wide slits and having generally a dwarfed appearance: this aspect passes rapidly, by a forward and upward thickening of the lips of the aperture and a general raising of the side walls and their throwing out lateral

extensions over the front wall, into the secondary form; in this a more or less round, slightly tubular aperture, partly embracing and partly overshadowing the oœcium, occupies the summit of a considerable eminence which has a long gradual slope down to the front wall, a short steep slope, sometimes vertical or even apparently overhanging, down to the succeeding zoœcium, and two lateral ridges formed by a pair of avicularia with their beaks pointing inwards; the primary front wall is left at a considerable depth below the general surface, all except its solid backbone, which is raised to such an extent that it generally touches the secondary front wall at the foot and often unites with it, thus linking it to the secondary front wall at the head by a longitudinal bar; the apertures left on either side of this bar are quite small, and the ribbed parts of the front wall are generally quite out of sight.

Oœcia small and globose: as a rule they are wholly enveloped in the eminence formed round the secondary aperture, but Fig. 9 illustrates a specimen in which this eminence has not been fully developed throughout and oœcia are partially visible here and there.

Avicularia very regularly present in pairs below and at the side of the aperture, appearing as swellings bearing on their outer slopes small elongated beaks with arrowhead-shaped apertures: these swellings roof in chambers which go down to the back wall, thus producing the typical Steganoporellan structure; unpaired avicularia may occur irregularly in other positions. This species occurs in the Norwich and Weybourne Chalk, and persists into the Trimingham Chalk, where it becomes scarce. It has a very considerable general resemblance to some forms of *Membraniporella castrum*, Bryd.,[1] from which it is readily distinguishable by the much greater length of uncovered front wall and the cavity just below the edge of the secondary aperture possessed by the latter.

MEMBRANIPORELLA PYRAMIDALIS, sp. nov. (Pl. IX, Figs. 10–12.)

This species is so closely akin to *M. transligata* that it can be best described by enumerating the points in which they differ. In this species the zoœcia are larger, the average length being from ·6 to ·7 mm.; the overlap of the primary front wall by the secondary one is more extensive; the primary front wall has much more slender ribs and looks decadent; there is only a single cavity of irregular but on the whole semicircular shape in the secondary front wall, as the primary front wall is never attached to it and is almost always wholly out of sight; the paired avicularia are similar internally, but externally are largely embraced by the apertural prominence, while the beaks stand out more and are longer, the points often impinging on the aperture, and very sharply defined, and give the apertural prominence the appearance of a pyramid, to which they contribute the angles.

This species is only known to me from the Trimingham Chalk. It has attained an almost Steginoporid structure by a route so wholly un-Steginoporid that another step along it could hardly fail to result in the total suppression of the Cribrilinid front wall and the

[1] GEOL. MAG., 1909, p. 398, Pl. XXII, Figs. 4, 5.

development—by completion of the secondary front wall—of a purely Lepralian form with Steganoporellan structure.

EXPLANATION OF PLATE IX.

(All figures × 12 diams.)

Fig. 1, 2.	*Membraniporella thoraciformis.*	Shawford, Hants.
,, 3.	,,	,,	Portsdown, Hants.
,, 4–7.	,,	*manonia.*	Portsdown, Hants.
,, 8.	,,	*transligata.*	Coltishall, Norfolk.
,, 9.	,,	,,	Trimingham.
,, 10–12.	,,	*pyramidalis.*	,,

II.—On the Integument of *Iguanodon bernissartensis*, Boulenger, and of *Morosaurus beckleshii*, Mantell.

By Reginald Walter Hooley, F.G.S.

(PLATE X.)

Integument of *Iguanodon bernissartensis*.

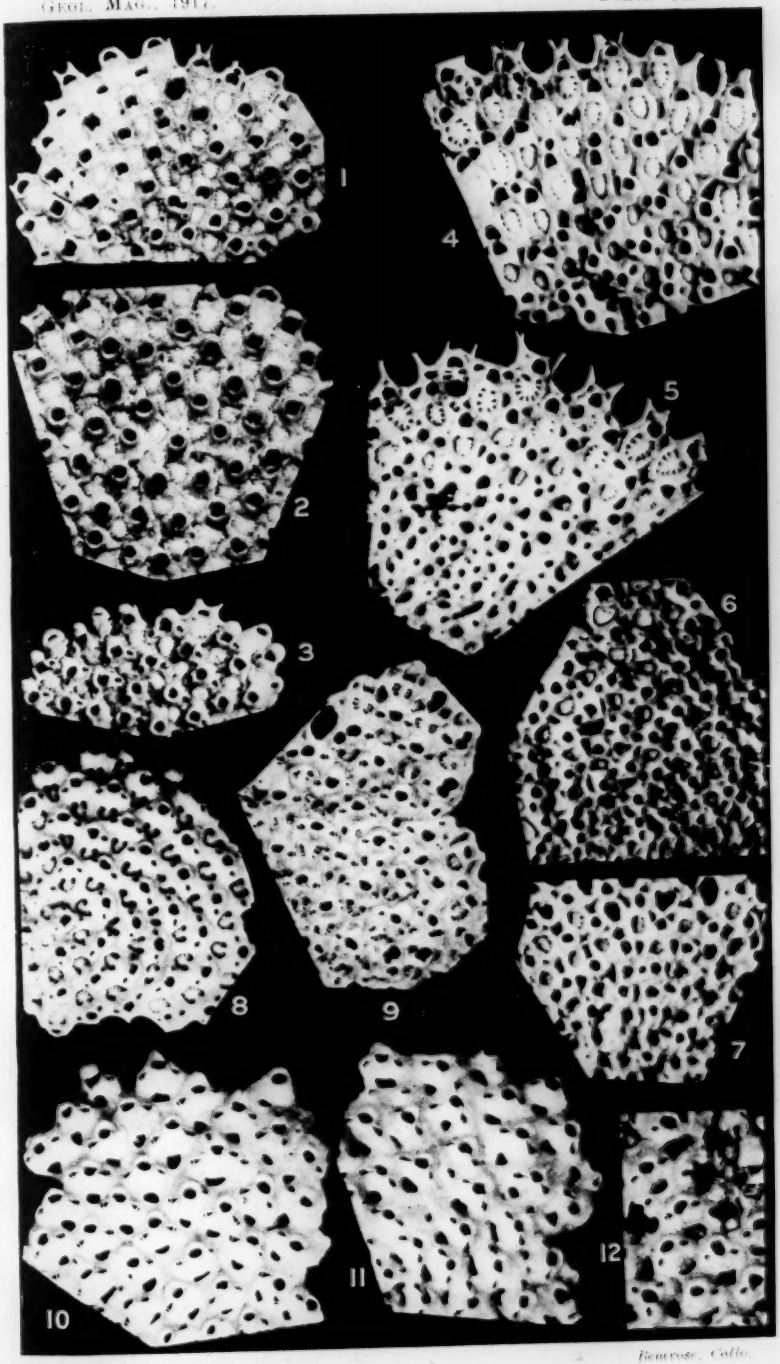
The *Iguanodon* has been known since 1825, when the genus was first described from teeth by Mantell.[1] Odd bones and various associated portions of the skeleton have been found in England, and in 1878 the skeletons of many individuals were discovered in the Wealden of Bernissart, near Mons, Belgium.

No trace of the dermal covering has hitherto been observed. Owen[2] in 1885, when describing the bones of a "young *Iguanodon*" from the Wealden of the Isle of Wight, mentions that "some portions of a layer of dark finely granulated carbonaceous matter were found embedded between the ribs, near the middle of the side of the trunk", which he queried as the integument of *Iguanodon*, but these remains were proved later to belong to *Hypsilophodon*.

In 1914 I obtained from the Wealden Shales of Brighstone Bay, Isle of Wight, nearly the entire skeleton of a young individual of *Iguanodon bernissartensis*, with the exception of the greater part of the tail.

In July last, while clearing away the matrix from the preacetabular extremity of the left ilium, a portion of the epidermis (Fig. 1) was exposed. It covers an area 90 mm. long by 40 mm. wide. The impression of the integument is also discernible on another block 78 mm. long by 57 mm. wide, found in close proximity to the other. Fragments of skin were also discovered underlying two of the left thoracic ribs. On these latter specimens carbonaceous matter is to be seen. No scutes or dermal ossifications were found. The skin is remarkably thin, and covered with small convex tubercles varying in diameter from 5 mm. to 3 mm. On the largest specimen there is an area, 8 mm. by 7 mm., where the tubercles are slightly larger and flatter, and 65 mm. distant occurs another patch with the same measurement, where the tubercles coalesce in such a manner that the tuberculation is almost invisible. The tubercles on the edge of the skin at the top

[1] G. Mantell, Phil. Trans., 1825, p. 184.
[2] R. Owen, Mon. Foss. Rept. Weald. Form., pt. ii, 1855, p. 51.



E. M. Bradone, Photo. Benrose, Calle.

Chalk Polyzoa.

of Fig. 1 are also decidedly larger and flatter than the others. One plate-like tubercle, 10 mm. in diameter, occurs on the smaller portion of the skin from the same inguinal region. It appears therefore probable that on those parts of the body exposed to the sun large flat tubercles would be found as in *Trachodon annectens*,[1] and it is evident that the "ground plan" of the epidermis is essentially similar, consisting of small, rounded tubercles, although in *Iguanodon* they are not so rounded or apical. Professor Osborn[1] thought that the iguanodonts from the Lower Cretaceous of Europe would probably be distinct in their "epidermal covering" from the trachodonts of the Upper Cretaceous of America, and it is interesting to find that at least they are alike in ground plan.

INTEGUMENT OF *MOROSAURUS BECKLESII*, MANTELL = *M. BREVIS*, OWEN.

An impression of the epidermis of this reptile (Fig. 2) is well displayed on a block of rock removed from the hollow between the radial crest and the inner border of the left humerus. This humerus, with the radius and ulna, was found in the Wealden beds of Hastings by S. H. Beckles in 1852. These specimens (No. R. 1870) are now in the British Museum. They were referred to by Mantell in a lecture given by him at the Royal Institution in that year. The report[2] of the lecture records that "A portion of the scaly cuirass which covered the limbs and is composed of hexagonal plates was exhibited". The integument was also noticed by Marsh,[3] when examining this fossil while still in the possession of its discoverer. He remarks that he "found attached to the humerus portions of the osseous dermal covering, the first detected in the *Sauropoda*, and known only in the present specimen". It has not been further described, but by kind favour of Dr. A. Smith Woodward I am now privileged to give the details.

The side of the matrix upon which the epidermal markings are shown is convex, well seen in Fig. 2, but this feature is entirely due to the concavity of the particular area of the humerus upon which it lay and not to the natural rotundity of the limb. There was no intervening matrix between the skin impression and the bone, therefore unless this portion of the integument was turned inside out after the decomposition of the muscles and before the matrix was deposited upon it, the under surface of the epidermis is exhibited. The only fact that supports the improbable theory of the reversal of the integument is that there is an apparent ornamentation of very small rounded tubercles displayed on some of the plates. The smallest plates, especially at the upper end of the specimen, are covered with them. It does not appear that they are due to oxidization subsequent to the removal of the block from the humerus. I have observed a somewhat similar result from chemical action after exposure to the atmosphere on matrix which at first had a smooth surface. However, it is more probable that they are papilliform

[1] H. Osborn, Mem. Amer. Mus. Nat. Hist., N.S., vol. i, pt. ii (June, 1912), pp. 46, 47.

[2] Proc. Roy. Inst., vol. i, p. 34, 1852.

[3] O. C. Marsh, GEOL. MAG. [3], pp. 205, 206, 1889.

protuberances of the epidermis into the dermis and that we are looking upon the inner surface of the former.

There is no sign of ossification, although Marsh[1] speaks "of the osseous dermal covering". The extent of the epidermal impression is 210 mm. long by 200 mm. wide. It consists of hexagonal plates, convex and boss-like, which on their outer surface were probably flat. A group comprising eight of the largest plates covers an area 95 mm. long by 68 mm. wide. The central plate of this group has a diameter of 26 mm. The plates surrounding this cluster gradually decrease in size, until they are only 9 mm. in diameter. The plates do not overlap. The integument of *Morosaurus becklesii* was tuberculate and the lessening in dimensions of the tubercles towards the axillary surface of the arm, where they probably became smaller and rounded, is after the manner of *Trachodon* and *Iguanodon*.

EXPLANATION OF PLATE X.

FIG. 1.—Impression of a portion of the epidermis from the left ilium of *Iguanodon bernissartensis* obtained by the author from the Wealden Shales of Brighstone Bay, Isle of Wight, in 1914.

,, 2.—Impression of a portion of the epidermis of *Morosaurus becklesii*, Mantell, found by Mr. S. H. Beckles in 1852 in the Wealden beds of Hastings, now in the British Museum (No. R. 1870).

III.—PICRITE FROM THE AMPWIHI RIVER, MOZAMBIQUE.

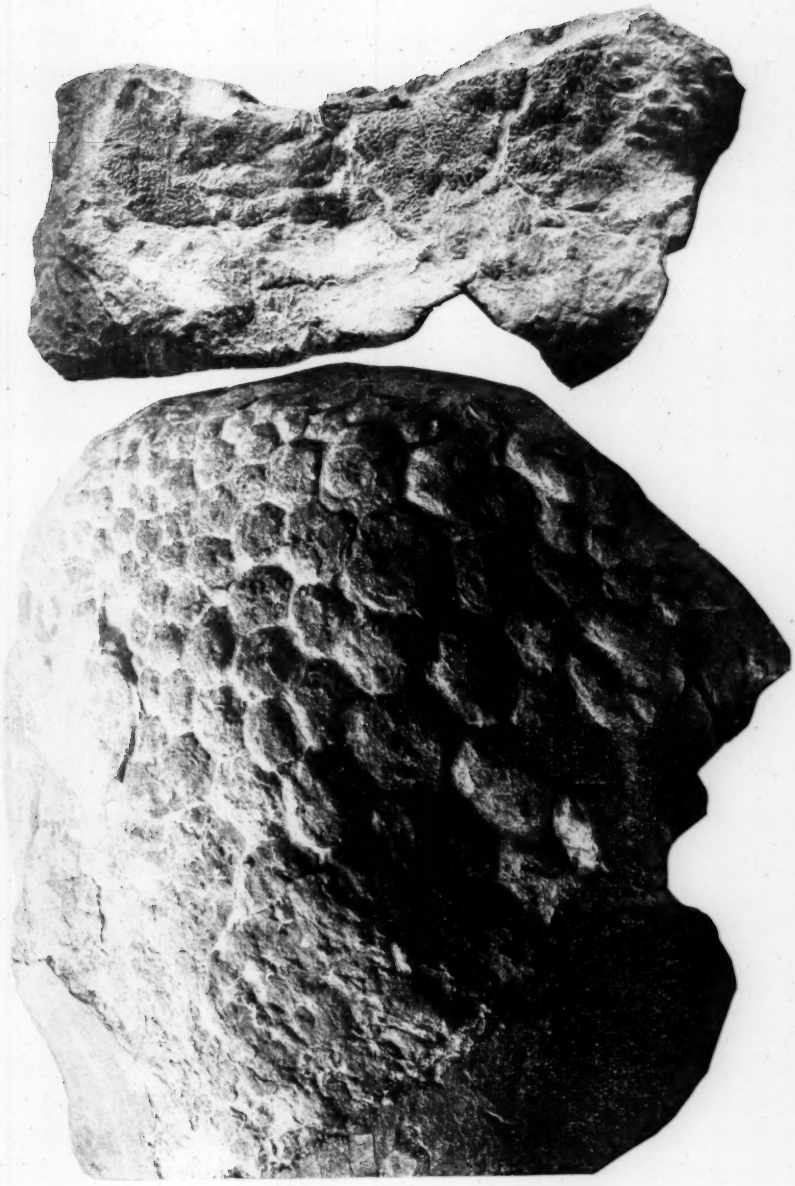
By ARTHUR HOLMES, A.R.C.S., D.I.C., B.Sc., F.G.S. (with an Analysis by H. F. HARWOOD, M.Sc., Ph.D.).

(PLATE XI.)

ALMOST due west of Mozambique Island, at a distance of about forty-two miles from the sea, the military road from Mosuril to Nampula crosses the Ampwihi River, an important tributary of the Monapo.[2] During the dry season the stream is reduced to a string of stagnant pools, separated by long reaches of sand and gravel that here and there are interrupted by outcrops of the underlying formations. Throughout the greater part of its course the Ampwihi flows through a region in which gneisses persist with monotonous regularity, the only variation being that due to occasional intrusions of granite and of still later pegmatite dykes. At the point where the military road crosses the narrow channel a welcome diversion is introduced by the presence of a dark compact dyke about 10 feet in thickness. The dyke appears on the right-hand bank and crosses obliquely to the other side, taking a N.N.W.–S.S.E. course across the strike of the older rocks. Upstream, about seventy yards to the south-east, the Ampwihi bends to the south-west, so that it returns towards the dyke, which is again exposed across its sandy floor. The dyke was traced by Mr. E. J. Wayland in July, 1911, for a distance of altogether 200 yards, and was examined by Mr. D. Alex. Wray and later by myself during the same year. It is clearly the latest

[1] O. C. Marsh, op. cit., p. 206.

[2] See A. Holmes & D. A. Wray, "Mozambique: a Geographical Study": *Geog. Journ.*, p. 143, Aug. 1913 (Map, p. 112).



PORTIONS OF INTEGUMENT OF WEALDEN DINOSAURS.

rock of the district, and is intruded along a line of fault, for in two cases pegmatite dykes seen on the eastern side are broken across and reappear on the western side with a well-marked northerly displacement.

Petrography.

The specimens collected were from the margin—evidently chilled—of the transverse dyke, and have a dark-grey colour, mottled with nearly black glassy phenocrysts of olivine. Here and there are minute white amygdales, the infilling consisting of an isotropic material that is probably glass. The weathered surface is creamy grey in colour with rusty patches corresponding to the phenocrysts. The average specific gravity of three fragments of the fresh rock is 3·08.

In thin section the rock is found to consist of corroded phenocrysts of olivine in a fine-grained groundmass composed mainly of elongated grains of augite and enstatite, the former alternating with and sometimes intergrown with laths of soda-lime felspar. In places interstitial patches of pale brownish-grey glass appear, and where a minute amygdale is seen it is found to be composed of the same obscure material (Pl. XI, Fig. 1).

The *olivine* phenocrysts are occasionally hyp-idiomorphic in outline, but generally they are deeply corroded, the resorption having sometimes divided a large crystal into a number of rounded fragments. Except around the edges and along cracks and cleavage planes, where serpentinization has begun, the crystals are still quite fresh. The serpentine is mainly of the fibrous variety, chrysolite, the fibres being arranged normally to the edges or cracks from which the alteration has developed. The only inclusions present are sparsely scattered grains of magnetite. In one section it was noticed that a shred of biotite had developed at the junction of an olivine crystal with interstitial glass.

The most abundant mineral of the groundmass, and indeed of the whole rock, is a pale yellow-green *augite* occurring in granules that are generally slightly elongated along the c axis. The average refractive index is 1·7; the optic-axial angle is low; and the specific gravity is nearer 3·2 than 3·1. These characters, when considered in relation to the chemical composition of the rock, indicate that the pyroxene approximates to the enstatite-augite variety.[1]

Among the augite granules there occur a few colourless grains generally of similar average dimensions, but occasionally slightly larger, having noticeably lower refractive index and double refraction, and giving straight extinction. They were at first thought to be wollastonite, but further optical examination showed that the optical character is positive and that the average refractive index is about 1·67. These properties lead to the conclusion that the mineral is *enstatite*. It is clear from its relations to the surrounding minerals that it crystallized after olivine and before augite. In Pl. XI, Fig. 2, a good example of enstatite can be seen adjoining the dark space on the right-hand side.

[1] See J. V. Elsden, Q.J.G.S., vol. lxiv, p. 287, 1908.

Between the grains of augite another colourless mineral, with prismatic habit, occurs. The optical characters indicate that it is a soda-lime felspar, approaching bytownite in composition. The average refractive index is about 1·57, and the maximum extinction angle is 40° measured from the direction of elongation of the microliths. As the specific gravity is estimated to be about 2·73, the composition of the felspar is approximately Ab_{30} An_{70}, i.e. that of a *calcic labradorite*.

The relations between augite and felspar are illustrated in Pl. XI, Fig. 2. A casual glance would suggest that the augite crystallized before the felspar, but this appearance is due to the superior relief of the augite, and a careful examination shows that the two minerals crystallized together. This conclusion is corroborated by the fact that in places a micrographic intergrowth can be detected. The augite grains become more angular, and between them the minute interstitial labradorite can be traced in optical continuity from place to place. On the borders of the micrographic areas the felspar frequently becomes fibrous and tends to radiate.[1] Becoming gradually more obscure the fibrous felspar dies away and an interstitial clearing of glass appears. The refractive index of the glass is 1·55, and its specific gravity is 2·5, indicating approximately the composition of syenite.[2]

The relative proportions of the minerals were measured by the Rosiwal method. Under a 1 in. objective the proportions of olivine and groundmass were determined, and afterwards the groundmass was analysed under a ¼ in. objective. As it was not found possible to distinguish in every case between augite and enstatite, the two pyroxenes were estimated together.

In order to determine the specific gravities of the various minerals, a diffusion column of methylene iodide and methylene iodide diluted with benzine was prepared so as to give a range from 3·3 to 2·3. Olivine and magnetite sank. A well-marked band of pyroxene formed between 3·1 and 3·2. Another band formed at 2·73 (labradorite), tailing out above and below owing to the difficulty of obtaining a clean separation from such fine-grained material. Finally, another layer formed at the level corresponding to 2·50.

The results obtained are as follows:—

Mineral.	Percentage by Weight.	Specific Gravity.
Glass . . .	8	2·50
Labradorite, An_{70} .	17	2·73
Pyroxene . . .	45	3·15 (average)
Olivine . . .	29	3·45 (?)
Magnetite . . .	1	5·17 (?)
Total . .	100 Average .	3·20

The actual specific gravity of the rock is 3·08, so that the figure assumed for olivine, 3·45, is probably a little too high. As the

[1] See Iddings, *Rock Minerals*, 2nd ed., fig. 28, p. 215, 1911.

[2] See J. A. Douglas, Q.J.G.S., vol. lxiii, p. 153, 1907, for relations between refractive indices and specific gravities of glasses.

analysis indicates that the composition of the olivine includes nearly 80 per cent of forsterite, the specific gravity should be about 3·4. This figure would give for the rock a calculated specific gravity of 3·10, which agrees more closely with the observed result.

Chemical Composition.

An analysis of the rock was made by Dr. H. F. Harwood, with the following results :—

	Percentages.	Molecular Proportions.	Mineral Composition (Norm.).	
SiO_2 . .	46·37	0·773		
Al_2O_3 . .	10·82	0·106	Orthoclase .	3·33
Fe_2O_3 . .	1·60	0·010	Albite . .	8·38
FeO . .	7·85	0·109	Anorthite .	23·33
MgO . .	20·78	0·5195		
CaO . .	7·94	0·142	Diopside .	12·82
Na_2O . .	0·99	0·016	Enstatite .	16·41
K_2O . .	0·57	0·006		
H_2O+ . .	1·97	—	Olivine .	30·30
H_2O- . .	0·82	—		
CO_2 . .	none	—	Magnetite .	2·44
TiO_2 . .	0·13	0·002	Ilmenite .	0·30
P_2O_5 . .	none	—		
MnO . .	0·16	0·002		97·36
Cr_2O_3 . .	0·07	0·0005	Water . .	2·79
NiO . .	0·07	0·001		
Total .	100·14		Total .	100·16

Specific gravity (average of three specimens) = 3·08.
Radium content (A. H. 1915) = $0·44 \times 10^{-12}$ grams per gram of rock.

The composition of the rock is of a type not very commonly found. Its nearest analogue is that of a Hawaiian picrite-basalt which was erupted in 1840.[1] A few other similar analyses are cited in the table below (p. 154), from which it may be seen that two British rocks, one from Anglesey and one from Loch Garabal, have a general chemical similarity to the picrite under discussion. The presence of nickel and chromium in every case in which it has been sought for is an interesting feature, and indicates the importance of making analyses as complete as possible. The association of these elements with olivine-rich rocks has been frequently pointed out,[2] and there is no doubt that by determining such relations in detail much may yet be learned concerning the genesis of igneous rocks and ore-deposits. Among African rocks the Mozambique picrite resembles most closely some of the mineralized picrites of the Insizwa Range.[3] Owing to the presence of pyrrhotite and of copper and nickel sulphides in these rocks the analyses cannot be directly compared, but it is clear that

[1] W. Cross, Prof. Paper 88, U.S.G.S., 1916, pp. 44, 77. The mineralogical composition of the Puna lava of 1840 is almost identical with that of the Ampwihi picrite.

[2] H. S. Washington, Trans. Ann. Inst. Min. Eng., xxxix, p. 735, 1908.

[3] W. H. Goodchild, "Economic Geology of the Insizwa Range": Inst. Min. and Met. (read December 21, 1916).

the two rock-types are very similar. In one case (sample No. 7) Mr. Goodchild remarks: "The felspars not infrequently show micrographic intergrowth with the pyroxene, but on the whole are interstitial," and in the photo-micrograph of the rock (Fig. 9) it can be seen that the correspondence in texture goes even further, for the olivines are markedly porphyritic. From nickel-bearing rocks we may turn to chromium-bearing rocks, as exemplified by those of the Great Dyke of norite of Southern Rhodesia.[1] Here, however, the picrites are coarse-grained, and are not comparable in detail, either texturally or mineralogically, with the Ampwihi picrite.

	A.	B.	C.	D.	E.
SiO_2	46·37	47·25	47·75	42·87	46·0
Al_2O_3	10·82	9·07	10·56	10·93	6·8
Fe_2O_3	1·60	1·45	0·74	3·44	3·0
FeO	7·85	10·41	8·34	10·14	7·5
MgO	20·78	19·96	19·09	16·27	23·9
CaO	7·94	7·88	9·62	9·11	8·1
Na_2O	0·99	1·38	1·32	0·92	0·8
K_2O	0·57	0·35	0·12	0·13	0·9
H_2O+	1·97	0·04	2·06	2·87	} 2·4
H_2O-	0·82	0·08	0·05	0·57	}
CO_2	none	—	—	2·70	n. d.
TiO_2	0·13	1·61	0·37	tr.	n. d.
P_2O_5	none	0·21	0·03	tr.	n. d.
MnO	0·16	0·13	0·10	tr.	n. d.
Cr_2O_3	0·07	0·13	0·24	n. d.	0·2
NiO	0·07	0·12	0·07	n. d.	n. d.
Total	100·14	100·03	100·46	99·95	99·60

A. Picrite. Ampwihi Crossing, Mozambique (an. Harwood).
B. Picritic basalt. Flow of 1840, Nanawale, Puna, Hawaii (an. Steiger).
C. Diabase? Cathay Hill, Mariposa County, California, U.S.A. (an. Hillebrand).
D. Hornblende picrite. Ty Crœs, Anglesey (an. Phillips).
E. Peridotite? Loch Garabal, Scotland (an. Player).

Returning to the analyses cited above, there are three further relationships worthy of discussion, namely, the relation of the MgO/FeO ratio to the percentage of alumina, the association of potash with magnesia, and that of soda with iron-oxides.

Vogt has shown that in peridotites the ratio of MgO to FeO increases on an average as the percentage of alumina decreases.[2] For percentages of alumina between 10 and 11 the atomic ratio of MgO/FeO averages 2·6. In the Ampwihi picrite there is considerable divergence from this value, the ratio being 4. There is a similar divergence in the case of the Cathay Hill Diabase, the ratio of which is 3·8. The three other rocks cited, however, give ratios that agree very well with Vogt's generalization :—

	D.	B.	E.
Al_2O_3	10·93	9·07	6·8
Atomic ratio MgO/FeO	2·2	3·0	4·2

[1] A. E. V. Zealley, Trans. Roy. Soc. S.A., p. 14, 1915.
[2] See A. Harker, *Natural History of Igneous Rocks*, p. 373, 1909.

Washington has recently pointed out the general sympathetic relation between potash and magnesia, and between soda and iron oxides in igneous rocks.[1] The former relation is exemplified with one exception (C) by the analyses quoted :—

	E.	A.	B.	C.	D.
MgO .	23·9	20·78	19·96	19·09	16·27
K_2O .	0·9	0·57	0·35	(0·12)	0·13

indicating that the Ampwihi picrite is not different from its analogues in this respect.

The soda-iron relationship does not hold within the narrow limits of the five analyses A–E. If soda and potash be compared with the MgO/FeO atomic ratio, however, it will be noticed that with one exception in each case potash increases, while soda decreases, with the ratio.

Atomic ratio of	E.	A.	C.	B.	D.
MgO FeO .	4·2	4·0	3·8	3·0	2·2
K_2O . . .	0·9	0·57	(0·12)	0·35	0·13
Na_2O . . .	0·8	0·99	1·32	1·38	(0·92)

It may not appear that there can be any meaning in such results as these, drawn as they are from rocks without apparent genetic relations in either time or place. Such rocks may, nevertheless, have genetic relations in virtue of the processes by which they were formed. By comparing similar igneous rocks, correspondences and discrepancies of the kind to which attention has been drawn may come to be used, when their significance is understood, to suggest the origin and differentiation of the magmas from which the rocks have crystallized. It is possible that magnesia-rich magmas do not readily part by crystallization with their potash, and that they may selectively absorb and accumulate potash from the rocks through which they pass in approaching the surface. Similarly, in proportion to their iron content, magmas may not readily part by crystallization with their soda, and they may selectively absorb and accumulate soda from the rocks through which they pass on their upward or lateral journeys. This digression has led us far from the picrite dyke of the Ampwihi River, to which we must now return to pick up afresh the lines of thought suggested by analytical results.

The radium content of the rock, only $0{\cdot}44^{-12}$ grams per gram, is very low. Peridotites appear to average more than this amount, a composite analysis of ten varieties giving $0{\cdot}51 \times 10^{-12}$ grams per gram.[2] Two dunites analysed for radium by Professor Strutt, however, gave $0{\cdot}33^{-12}$ and $0{\cdot}34^{-12}$ grams per gram respectively.[3] The slightly higher result for the picrite is probably due to the presence of felspathic constituents, which are generally far richer in radium than olivine or enstatite. The result is of more than numerical interest merely, for it shows that the dyke cannot have

[1] Proc. Nat. Acad. Sci., p. 574, 1915.
[2] A. Holmes, *Science Progress*, 1914, No. 33, p. 16.
[3] R. J. Strutt, Proc. Roy. Soc., 1906, A. 77, p. 479.

derived its felspathic constituents by any process of absorption. Had this been the case the radium content would undoubtedly have been higher.

Cooling History.

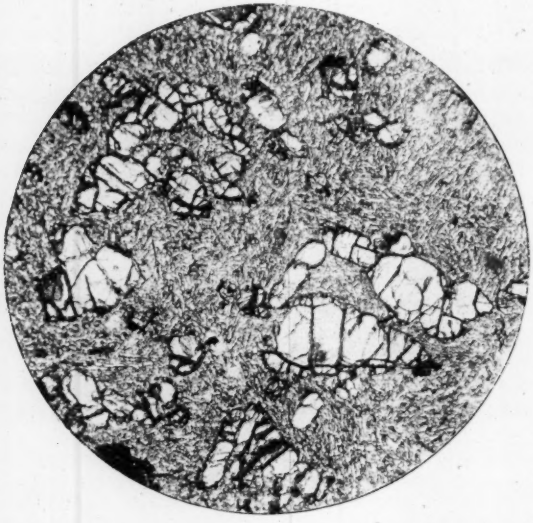
The order of crystallization has already been indicated in the description of the various minerals. It may be summarized as follows: (*a*) magnetite; (*b*) olivine, afterwards partly resorbed by the magma; (*c*) enstatite; and (*d*) augite and calcic-labradorite; leaving (*e*) a residuum of glass.

This cooling history is of particular interest since it is closely paralleled by that of one of the artificial melts described by Andersen in his paper on the Anorthite-Forsterite-Silica System.[1] The ternary diagram (fig. 9, p. 437, op. cit.) represents the cooling history of any melt containing only the three constituents mentioned. The melt chosen for comparison has a composition equivalent to 60 per cent of forsterite, 15 per cent of silica, and 25 per cent of anorthite. This mixture is expressed in the ternary diagram by a point which lies well within the forsterite field of crystallization. Forsterite is therefore the first mineral to crystallize, and it continues to do so until the falling temperature brings the system to the boundary-line between the fields of forsterite and clino-enstatite. When this line is reached 37 per cent of forsterite has crystallized. Now, however, the further evolution of the system proceeds along the boundary-line in such a way that clino-enstatite is separated, while forsterite is slowly resorbed by the liquid. Ultimately a point is reached between the clino-enstatite and anorthite fields of crystallization, and at this stage 21 per cent of clino-enstatite has crystallized, while the forsterite has been reduced to 34 per cent. During the completion of the crystallization the temperature continues to remain constant. More forsterite is resorbed, reducing its percentage to 25, while clino-enstatite and anorthite crystallize out together, the final proportions of these substances being 50 per cent and 25 per cent respectively.

In the picrite described in this paper the actual minerals are analogous to those of the artificial melt. Instead of forsterite we have olivine, of which about 80 per cent is forsterite; instead of clino-enstatite we have enstatite, followed by enstatite-augite; and instead of anorthite we have a calcic-labradorite containing about 70 per cent of anorthite. The percentages are also very similar, being approximately in the proportion 30 : 40 : 30, instead of 25 : 50 : 25. In an artificial melt of the former composition the ternary diagram shows that the cooling history would be the same as in that outlined above. The crystallization of the picrite was, of course, relatively complicated by the presence of iron and alkalies, but these do not appear to have appreciably affected the salient features of the cooling history. The rock itself, as portrayed by the

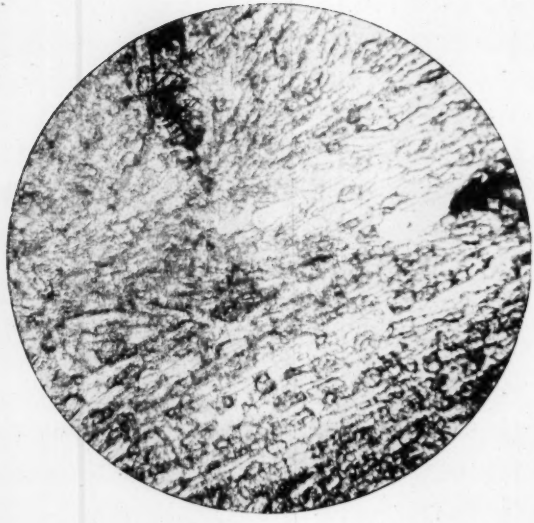
[1] Olaf Andersen, *Amer. Journ. Sci.*, xxxix, p. 407, 1915 (see in particular figs. 9 and 11 and table viii).

1.



× 25

2.



× 25

PICRITE FROM MOZAMBIQUE.

photographs of Plate XI, gives visual proof that the same course was followed as in the artificial melt. It should, however, be mentioned that part of the soda-lime felspar probably enters into the crystal framework of the augite, while another part may remain hidden in the residual glass. The presence of a minute reaction rim of biotite between olivine and the glass further suggests that the latter may contain the constituents of orthoclase. Consequently the actual amount of felspar in the rock is less than that calculated from the analysis, while the pyroxene appears to be correspondingly more abundant.

In conclusion, I wish to express my thanks to Dr. H. F. Harwood for his collaboration in making the analysis, and to Mr. G. S. Sweeting for taking the micro-photographs with which the paper is illustrated.

EXPLANATION OF PLATE XI.

FIG. 1.—*Picrite* from the Ampwihi River, Mozambique. Corroded phenocrysts of olivine, serpentinized along cracks, are seen in a fine-grained groundmass. × 25 diameters.

,, 2.—*Groundmass* of picrite from the Ampwihi River, showing grains of augite lying amongst parallel or radiating laths of labradorite. In places the two minerals show graphic intergrowth. On the right-hand side a rounded crystal of enstatite of earlier crystallization than the rest of the groundmass can be seen. × 125 diameters.

IV.—Disturbed Gravels.

By R. M. Deeley, M.Inst.C.E., F.G.S.

THERE are many features characterizing the surface portions of deposits which are very puzzling. Indeed, the more one studies them the less one is inclined to be dogmatic. Many true glacial deposits show remarkable signs of disturbance throughout their mass. We may instance the Contorted Clay of Norfolk as a case in point. Even when boulder-clays are too uniform in texture to show signs of movement they are often kneaded into the rocks upon which they rest, and rocks of all ages often show such disturbances when they have been overridden by ice. Here we are dealing with the results produced by the action of forces operating from without the deposit.

In other cases, as I have attempted to show,[1] the effects can be accounted for in the supposition that we have heavy beds of gravel or gravelly clay sinking into soft lighter clays or marls below. The trail and underplight of Spurrel seems to be caused by such movements.

There are disturbances, however, which it seems to be impossible to account for in this way. I refer to the peculiar signs of movement shown by gravelly and sandy deposits, even when they lie outside the areas which we know to have once been covered by ice-sheets. They are to be seen in many of the gravels and sands of the South of England, and also in river gravels, which there is reason to

[1] Geol. Mag., 1916, pp. 2–5.

suppose have never been covered by glacier ice, even when occurring within the glaciated areas. When studying the deposits of the Trent Basin [1] I was very much interested in these surface features. They were never seen in the low-lying gravels; but always very marked in those resting with their upper surfaces 25 feet or more above the alluvial plain. That they were due to the action of ice in some form or other seemed the only possible explanation. At that time, and indeed until I had seen some of the Thames gravels, the most likely theory of their formation seemed to be the movement over them of glacier ice for very short periods of time. This seemed to be supported by the trend of the axes of the disturbances, which was almost, if not always, such as to indicate a movement down the valleys.

Another peculiar feature of these surface disturbances in the Trent Basin deserves notice. In this area we have fluvio-glacial gravels of two very different lithological characters. The one was formed by ice which came from the west, and is destitute of flints where undisturbed. The other contains flints throughout, having an easterly origin. For the flints to penetrate several feet deep into the flintless deposit was a great difficulty, and seemed to require the operation of a force acting from without.

If ice in glacier form be out of the question on the south side of the Thames Valley, another explanation must be looked for. The explanation about to be proposed requires further field work before it can be accepted as correct; for it is necessary that what is now going on in very cold climates should be more carefully studied.

Fig. 4, p. 471, in my paper on the Pleistocene Deposits of the Trent Basin,[2] shows a typical form of the phenomenon. Here we have rising up towards the surface waves composed of very complex masses of sand and gravel. Between these waves lie deposits of more sandy material containing pebbly festoons and streaks. At their bases the "waves" consist of the disturbed gravel and sand beds below; but as we rise the deposit becomes less and less stratified and finally loses all signs of stratification. The material between the waves of gravel is quite sandy and shows traces of very irregular bedding. It is remarkably like a rainwash we should expect to be derived from the gravel, and it retains this character even when the pockets penetrate as much as six feet into the hollows between the waves. But how can we account for rainwash in such a position? The sides of the gravel waves are too steep for them to have existed without the rainwash in their troughs.

The phenomena we are dealing with may have been formed in the following manner during periods of intense cold. During the summer the whole mass thaws, and the water-level in the gravel lies five or six feet below the surface. In the winter the frost penetrates the gravel, but does not disturb it until the water-level is reached. As the water freezes the ice expands sideways as well as vertically. But it is not free to expand horizontally everywhere. Imagine that it expands over definite areas and that crushing takes place on the

[1] "The Pleistocene Deposits of the Trent Basin": Q.J.G.S., 1886, pp. 437–79.

[2] Q.J.G.S., 1886.

margins of these areas, and that when crushing goes on the deposit rises and raises ridges on the surface of the ground. We should then have on the surface of the ground a complicated series of ridges with numerous hollows between them. During periods of thaw the finer material would be washed into these hollows.

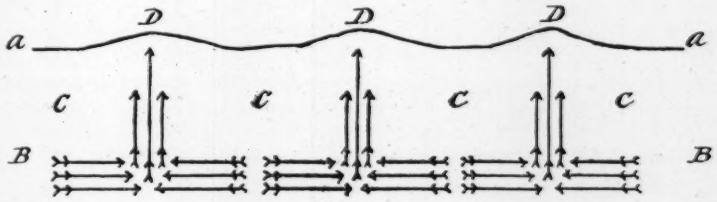


Fig. 1 shows diagrammatically how this process is supposed to take place. A A is the ground-level and B B the water-level in the gravel and sand. When the frost reaches the water-level expansion takes place and there is movement in the direction shown by the arrows. Below the points marked D the gravel and sand rise and ridges are raised on the ground surface; when thawing occurs the loose material of the ridges is washed into the hollows. We thus have the material rising at D D and sinking areas at C C C. Eventually troughs of rainwash form at the points C and gravel waves below the ridges D.

It is possible that when once lines of weakness had been formed in the gravel below the surface, crushing generally goes on along the same lines each winter, and that rainwash collects in the same hollows each summer. A repetition of this process results in the formation of waves of gravel separated by troughs of rainwash. Much would depend upon the water-level in the gravel and the direction of the water circulation in the gravel. It may be that the waves and troughs tend to arrange themselves parallel with the direction of the underground flow.

If such an explanation be the true one, we should expect to find such ridges and hollows on the surface of gravel deposits in Arctic regions. Various patterns have been noticed on the surface of the ground in high latitudes, and it would be well to examine them very carefully.

Any surface stones or flint implements resting on or near the surface would, if the above theory be correct, get buried deep in a deposit with which they are not contemporaneous. In some such way flints have been buried five or six feet deep in deposits which did not originally contain flints; indeed, it has always seemed surprising how foreign articles have managed to bury themselves so deeply even in gravelly deposits. It is necessary in all cases to make sure that flint implements are in undisturbed bedded gravels and sands; for if they are not they may have been introduced long after the deposit was formed.

V.—Morphological Studies on the Echinoidea Holectypoida and their Allies.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

Foreword.

During the past seven years I have published several papers based upon preliminary investigations on the anatomy of the Holectypoida, an order of the Euechinoidea which, by general consent, is regarded as transitional between the Regular and Irregular sections of the class. Continued study, aided by increased mental and technical experience, has revealed an ever-increasing number of interesting features in the order, and has made possible more definite and confident surmises as to its affinities with other groups. The series of contributions here commenced is intended to amplify, and in some cases to correct, the statements made in my earlier papers. With very few exceptions the actual descriptions that are given in the former work still seem to be essentially correct, but every fresh examination, even of the same specimens, testifies to the incompleteness of most of the observations hitherto published. New material, better or differently preserved, often draws attention to features overlooked or discarded as unimportant in the examples already studied. No apology is needed for the publication of incomplete descriptions of natural objects, since complete knowledge is as yet nowhere attained. When inaccuracies of observation have been detected, their nature and cause will be stated frankly, accompanied, verbally or not, by suitable contrition.

But in matters of theory—the tracing of phyletic series and of the trend of structural evolution—the contrast between my present views and those previously held and expressed is likely to appear more marked. A structural feature overlooked or misunderstood may be added to, or modified in, a description without seriously altering the whole; but when the corrected knowledge is applied to a theory, it may produce a veritable revolution. Nevertheless, if the formulation and publication of theoretical conclusions were to be postponed until a basis of complete knowledge is attained, science would speedily sink into a state of encyclopædic chaos, without so much as an alphabetical classification in which to wrap its disjointed facts. Much of the progress of science is achieved by reasoned attacks upon established theories, and if it is legitimate and profitable to demolish the flimsy edifices of others, it is surely less invidious and more seemly to treat similarly the product of one's own imperfect efforts. So that it will be with joy in the new and better building, rather than with regrets and apologies for the earlier erections, now obsolete and superseded, that the fresh theoretical opinions will be raised. To suggest that the new theories are correct in detail would be ridiculous, but they are more securely founded than the former ones, and can yield place only to a better series, based upon more complete knowledge.

I have chosen the serial method of presenting my results, partly on account of their bulk, and partly because the aspects of the

Echinoidea covered by my researches are so various that some sections will be independent, in all but their ultimate aim, of the actual order Holectypoida. Much of the work is concerned with recent forms (partly with their histology), some deals entirely with fossil genera and species, and some is largely stratigraphical in treatment. It is obvious that such diverse sections will affect workers in very different spheres, who will not wish to be burdened with a cumbrous mass of details which have no direct bearing on their particular branch of study. Glory and honour accrue to the author of a massive tome, but understanding and gratitude are the reward of the writer of pamphlets.

As far as possible it is intended that the earlier sections of the work shall deal with matters of fact and observation, so that the theoretical conclusions derived from them may be concentrated into the later parts, and be more or less synchronous in their appearance and homotaxial in their expression. I hope to publish the shorter sections (or those of them that deal with subjects of a palæontological or geological character) in this Magazine, in continuation of the earlier series, most of which appeared here. Larger, or purely zoological, sections will necessarily demand a different environment. Unlike serial publications in the domain of fiction, each part will aim at being complete in itself, in the light of its predecessors, for, in the world as at present constituted, it is a rash, if not a provocative, prophecy to announce that any form of activity will be "continued in our next".

I. Systematic Discussion of the genera *Pygaster*, Agassiz, and *Plesiechinus*, Pomel.

1. Introduction.

The conservatism of the Holectypoida, and in particular of the family Pygasteridæ, while rendering the order a favourable group for phylogenetic study, has been a condition contributory to the utmost systematic confusion. It is to be hoped that there are few orders, so small numerically, whose nomenclature is so involved. To a considerable extent the lamentable taxonomic chaos into which the family has fallen, is due to the two common causes of such a state—inadequate description and erroneous identification of species. Other preventable errors have been numerous, but the root of the trouble is buried in the nature of the family itself. Where evolution is almost stagnant, even generic differences will be slow to appear and indistinct in their early stages; specific characters must be still less clearly defined. In default of any striking features by which to diagnose their types, authors have tended to use as specific criteria such variations of form and detail as would be considered unworthy of more than passing reference in more plastic groups. Finally, when there is added to these difficulties the fact that the genotype of *Pygaster* was subsequently degraded to the position of a synonym, and, when revived, imagined to be a form from a totally different horizon, and belonging to a different section of the family, it will be realized that a systematic revision of that genus is a necessary preliminary to any morphological study of its species.

Unfortunately, the two specific names most familiar to British geologists ("*P. semisulcatus*" and "*P. umbrella*") have to be changed. The impersistence of palæontological nomenclature is a source of considerable difficulty to students and teachers, and of ironical amusement to those less intimately affected. The trouble is aggravated by the fact that abundant and early known species reflect most frequently the flickering light of systematic research. Realizing to the full, by personal experience, the gravity of the confusion caused by such changes, I sought long for a loophole through which the current nomenclature could be thrust. But I am convinced that there is none. A shelving of the matter would only postpone the inevitable rectification, and meanwhile involve the whole subject in greater confusion. If the truth will out, then the sooner the better. With the hope of making this unpleasant change final, I have studied and catalogued upwards of 400 papers that had any bearing, however remote, upon the question. As a result I feel confident that no further alteration, depending upon past literature, will be necessary for any who are willing to follow logically and impartially the laws of nomenclature. No excuse is necessary for the amount of space devoted to this least inspiring aspect of the forms to be discussed, since it can there be seen on what evidence the changes are made; and, if any error or omission occurs, speedy correction can be made.

In respect of the generic classification, no essential modifications are introduced. The scheme adopted by me in 1912 (Proc. Zool. Soc.) seems adequate, as far as concerns the family under review. Apart from alterations in nomenclature, to be discussed later, the chief difference in the present arrangement lies in the elevation of the subdivisions, previously suggested as subgenera of *Pygaster*, *s. lat.*, to the rank of independent genera. The reasons for this change cannot be considered here, but will, I believe, obtain justification when their morphological basis is published.

2. The Type of *Pygaster*, Agass.

The genus *Pygaster* was founded by Agassiz in 1836 (*Prodrôme*) to include two species, *Clypeus semisulcatus*, Phillips, and *Nucleolites depressus*, Münster in Goldfuss. The species were mentioned in this order, and, since the former conforms more closely to the brief diagnosis first given, it must be regarded as the genotype. *Nucleolites depressus* is an entirely different form. In 1839 Agassiz, giving the first full description of the genus, accompanied by that of several species, omitted to include either of the forms for which he had originally proposed it. He stated (*Ech. Suisse*, p. 80) that he knew of six species, three from the Cretaceous and three from the Jurassic. Of the Cretaceous types, *Macropygus truncatus* was probably one, and *Anorthopygus orbicularis* may have been another, but a third was never described by him. Four Jurassic species are recognized in the work, in spite of the reference to three only in the generic discussion; they are *P. laganoides*, *P. patelliformis*, *P. tenuis*, and *P. umbrella*. There is thus no reference to the genotype. When the name *semisulcatus* reappears (Desor, *Mon. Gal.*, 1842) it is found as a synonym of "*P. umbrella*". The dire confusion that subsequently

befell the nomenclature of two important species is dealt with in the next section.

For the present purpose it is sufficient to note that there exists such a species as *Pygaster semisulcatus*, figured by Phillips (*Geol. Yorks.*) under the name of *Clypeus*, though not described by him; and that it was originally found, and may yet be collected, in the Coralline Oolite of Malton. This form must, then, represent the type of *Pygaster*, the Inferior Oolite species to which the name has been most frequently applied, being here regarded as not even congeneric. *Pygaster*, with its restored genotype, will include three of the four species described by Agassiz in 1839—*P. patelliformis*, *P. tenuis*, and "*P. umbrella*"—and so may be taken as expressing most adequately the original meaning of its author. It will absorb the subgenus *Megapygus* proposed by me in 1912, that name having been given in ignorance of the real meaning of the term "*P. semisulcatus*".

3. The Name *Pygaster semisulcatus*, Phillips, sp.

The name *Clypeus semisulcatus* was given in 1829 by Phillips (*Geol. Yorks.*) to a species from the Coralline Oolite of "Malton, Scarborough, and Wiltshire". No description was published, but a recognizable figure (reduced in size and obliquely adapical in view) was printed. Forms conforming in character to that figured may still be found at the first locality mentioned, and, since no other echinoids at all similar occur there, no doubt can exist as to the species intended. The actual specimen used for the drawing cannot be traced, and has probably suffered the fate of many of Phillips' types. The absence of a holotype is particularly unfortunate, since much confusion surrounds the application of the name. As will be seen later, it is necessary to select a specimen as a lectotype.

In 1836 Agassiz included *C. semisulcatus* in his new genus of *Pygaster*, of which it must be regarded as the type. He would appear to have been guided solely by the figure published by Phillips. In 1839 Agassiz refers presumably to this species (*Ech. Suisse*, p. 79). Apart from a casual reference, however, *P. semisulcatus* does not appear in the work, and, to judge from the evidence available, Agassiz must have considered it synonymous with one of the species there diagnosed, probably with *P. umbrella*. Desor, in 1842, was more explicit (*Mon. Gal.*, p. 77), inserting the name in the list of synonyms of *P. umbrella*. On p. 76 he says that *C. semisulcatus* "pourrait fort bien n'être autre chose qu'un jeune de notre *P. umbrella*". Since Phillips' figure was, according to Forbes, two-thirds the size of its original, the dimensions of the Yorkshire specimen will have been not far short of those of the Swiss *P. umbrella*, their identity being thus rendered more possible. It is necessary, then, in view of the conceivable identity of *Clypeus semisulcatus*, Phill., and *Pygaster umbrella*, Agass., 1839, to discuss briefly the justification for the former name. Obviously, if the two names apply to the same species, that of Agassiz, supposed to be derived from Lamarck (1816) and perhaps from Leske (1778), would have priority.

There can be no doubt that the figures of *Galerites umbrella* in the *Encycl. méthod.* (pl. cxlii, figs. 7, 8) represent a species of *Clypeus*, presumably *C. sinuatus*, Leske. The descriptions given by Lamarck, Deslongchamps, and de Blainville all agree more closely with the generic characters of a *Clypeus* than of a *Pygaster*. Agassiz (1839) hesitated to include *C. sinuatus*, Leske, in his list of synonyms of *P. umbrella*, although he inserts the *Nucleolites umbrella* of Desmoulins, which included Leske's species. Desor (1842), following on and amplifying the descriptions of Agassiz (probably with his collaboration), definitely placed *Clypeus sinuatus* among the synonyms of *P. umbrella*, and, to complete his identification, inserted a reference to the description and figure given by Klein (1734) as *C. plotii*. In 1847 (*Cat. Rais.*) both authors jointly recognized the error of including *Clypeus sinuatus* in the genus *Pygaster*, and deleted all the previous synonyms of *P. umbrella* except the reference to Lamarck. They gave to the original *P. umbrella* the new name of *P. dilatatus*, and, to add to the confusion, briefly diagnosed a new species under the old name; surely a most disastrous way of rectifying a mistake! With this complication, however, we are not immediately concerned. The question of the relation between the names *semisulcatus* and *umbrella* (supposing them to refer to the same species) turns on the description of *Galerites umbrella* by Lamarck. The use of the generic term *Galerites* affords no guidance, for Lamarck applied it to many forms which cannot be classed as Holectypoida. He gives a reference to *Clypeus sinuatus*, Leske, and to the figure in the *Encyclopédie* (Lamarck, *An. s. vert.*, iii, p. 23), and describes his *Galerites umbrella* as "sulcis ambulacrorum angustis biporosis substriatis". As Salter remarked (Mem. Geol. Surv., Dec. V, 1856), the last word seems to imply a petaloid or subpetaloid ambulacral structure that is incompatible with the characters of a *Pygaster*. There seems, therefore, little doubt that Lamarck's species was a *Clypeus* or a *Nucleolites*, and was thus in no way to be identified with the *Pygaster umbrella* of Agassiz in 1839, nor with the later species given that name in 1847.

Since all the references given by Agassiz in 1839 for *P. umbrella* seem to have no real connection with that species, it follows that the name *P. umbrella*, Agassiz, 1839 (*excl. syn.*), can be applied only to the form figured by him—known at that time by a unique and partly decorticated specimen, from the "Portlandien du Jura Soleurois". The name itself, denuded of its list of synonyms, is valid enough, but it dates back no further than 1839. Hence, if *Clypeus semisulcatus*, Phill., and *Pygaster umbrella*, Agass., are synonymous, the former name has ten years priority, and can in any case be maintained.

Morris (*Cat. Brit. Foss.*, 1843), and later Salter (loc. cit.), recognized the true nature of Lamarck's *Galerites umbrella*, and followed Desor in his identification of the two species, but naturally regarded *P. umbrella* as a synonym of *P. semisulcatus*. Unfortunately Salter's *P. semisulcatus* was quite a different species from Phillips' original one, so that the way to further confusion was opened by his otherwise logical action.

It seems doubtful whether any reliable specific criteria can be

recognized in the original specimen of *P. umbrella*, Agass., 1839. The bad preservation of the type makes reference of other specimens to it dangerous. If the species usually called *P. dilatatus* (the second name given by Agassiz to his former *P. umbrella*) is really that of 1839, then it may be stated with confidence that it is not synonymous with *P. semisulcatus*. I have shown above that, whatever might be the result of such an inquiry, the name *semisulcatus* is either independent of, or must supersede, that of *umbrella*.

Having established the legitimacy of the specific name *Pygaster semisulcatus*, we can turn to the history of its use by British authors.

For sixteen years after the publication of *Clypeus semisulcatus*, that species was the only *Pygaster* recognized by name in Britain. Indications that another species had been collected are to be found in Morris (loc. cit., 1843), where *P. semisulcatus* is recorded from the "Great Oolite" (really Inferior Oolite) of Gristhorpe, Yorks, in addition to its original Corallian localities. It seems, however, that very great confusion existed as to the generic character of the Corallian Pygasters. Parkinson (*Org. Rem.*) referred to *Clypeus sinuatus* specimens from the Coral Rag of Berkshire and Oxfordshire, which were in all probability species of *Pygaster*. Conybeare and Phillips (*Geol. Eng. and Wales*) followed him in regarding *C. sinuatus* as a characteristic fossil of the Inferior, Great, and Coralline Oolites; and, as late as 1850, Mantell, in republishing some of Parkinson's drawings, emphasized the frequent occurrence of *C. sinuatus* in the Corallian. It is true that species of *Clypeus* and *Pygurus* have been found in the British Corallian, but they are extremely rare, so that it is most improbable that these references actually apply to them.

In 1844 Buckman (Murchison's *Geology of Cheltenham*), recognizing the difference between the "*Clypeus*" of the Inferior Oolite of the Cotteswolds and that of the Corallian, distinguished the former species as *C. ornatus*, and in 1848 M'Coy (*Ann. Mag. Nat. Hist.*) gave the name *Pygaster brevifrons* to a form from the Inferior Oolite of Dundry Hill. The latter author followed Agassiz and Desor in their identification of *Clypeus semisulcatus* with *Pygaster umbrella* (M'Coy, loc. cit., p. 414), and recorded a specimen from the Coralline Oolite of Malton under the latter name (id., p. 420).

The first published reference of the name *P. semisulcatus* to the Inferior Oolite species seems to have been that by Brodie (Q.J.G.S.) in 1851. His identification of the Cotteswold forms with the Yorkshire species was probably influenced by Wright, who, in the following year (*Ann. Mag. Nat. Hist.*), united under the one specific name forms from the Pea Grit, Great Oolite, and Coralline Oolite. Forbes in 1854 (*Morris' Cat.*, 2nd ed.) endorsed the identification of these diverse species, still citing *P. umbrella*, Agass., 1839, as a synonym. Two years later (Mem. Geol. Surv., Dec. V) he repeated the error, identifying actual specimens from the Inferior Oolite of Gloucestershire and the Coral Rag of Faringdon under the name *P. semisulcatus*.

It is important to realize the prevalence of this belief in the occurrence of the same species of *Pygaster* in the Corallian and Inferior Oolite, because Phillips, when asked by Forbes to supply

a typical specimen of his *C. semisulcatus*, sent a specimen from the Inferior Oolite of Whitwell. The actual holotype was lost by this time, so that this specimen came to be regarded as the true representative of the species, in defiance of the references of 1829.

The year 1856 was a critical one in the history of the specific name. Both Wright and Salter then came to recognize the essential difference between the lower and middle Oolitic species, and, owing to Phillips' error, applied the name *semisulcatus* to the Inferior Oolite form. The degree of confidence, coupled with lack of logic, with which this wrong determination was made, can be gauged by the following quotation from Wright (Pal. Soc., Ool. Ech.): "It was an error in the determination of the species, which led Professor Phillips to state that *Pygaster semisulcatus* was found in the Coralline Oolite of Yorkshire, that form never yet having been found in Yorkshire out of the Whitwell beds—Inf. or Great Oolite." It is difficult to understand how an author could be in error in the determination of a *new* species at the time when he first recorded and figured it, especially since the other form with which he is supposed to have confused it had not been recognized at the time; but it was from this paradoxical conclusion of Wright that issued all the confusion in the misapplication of the name. Save for a passing reference by Desor (Synopsis), the name *Pygaster semisulcatus* has not been applied to a Corallian species since 1856!

Apart from the fact that the original reference to *Clypeus semisulcatus* included solely Corallian localities, the figure given, though imperfect in some respects, shows quite clearly the pyriform shape of the periproct—a feature utterly unlike anything found in any Inferior Oolite species. The climax of the unnecessary confusion introduced in 1851 is found in the third edition of Phillips' work (by Etheridge) in 1875. Here the original figure of 1829 is reprinted, and referred to as *Pygaster umbrella*, Agassiz, while the name *semisulcatus* is transferred to the Whitwell forms on the same page. Such a glaring absurdity cannot be allowed to remain.

As stated above, the type of *Clypeus semisulcatus* was lost before 1856, and has not been seen since. Even if it is still in existence (or if any one specimen was actually selected in 1829), it would be impossible to identify it with certainty. No description or measurement was given, nor could the latter be deduced from the drawing. This is said to be two-thirds of the natural size, but, since the specimen is viewed obliquely, neither diameter nor height could be accurately calculated. It becomes necessary, therefore, to select a specimen to replace the missing holotype, so that future references may rest on a more secure foundation than hitherto. Malton was the first mentioned locality, and from the quarries near that town specimens are still obtainable. A very beautiful specimen from this locality is in the British Museum (No. E 1645). It is the one used by Wright for his drawings of the adoral surface and apical system of "*P. umbrella*" (Pal. Soc., *Ool. Ech.*, pl. xx, figs. 2*b*, *e*), and I hereby select it as the lectotype (also a topotype) of *Pygaster semisulcatus*, Phill., sp. This specimen thereby becomes the type of the genus *Pygaster*, Agass.

For the species from the Inferior Oolite, so long miscalled *P. semisulcatus*, the name *Clypeus ornatus*, Buckman, 1844, is available. This has clear priority over the only other specific name applied to the species during the period of its recognition (*P. brevifrons*, M'Coy, 1848). This form must in future be known as *Plesiechinus ornatus*, Buckman, sp.

4. The type of *Plesiechinus*, Pomel.

This genus was proposed in 1883 by Pomel, to include those species of *Pygaster* whose characters show the nearest approach to those of the Regular Echinoids. Three of such species were mentioned by him: *P.* "*megastoma*", Wright, *P. semisulcatus*, "Wright," and *P. speciosus*, "Quenst." One of these three must be the genotype. *P. speciosus*, "Quenst.," the last mentioned, is by no means well known (supposing it to be the *Nucleolites speciosus* of Goldfuss), and may not belong to the Pygasteridæ. The name *P. semisulcatus*, "Wright," refers to the most abundant and best-known species of the three, but unfortunately it is not the true *P. semisulcatus* (Phill.). It would be confusing to implicate the generic name in the systematic turmoil surrounding the species. The choice will fall, therefore, upon *P.* "*megastoma*", Wright. In spite of its author's doubts as to its separation from his *P. semisulcatus*, the two species are quite distinct, in both characters and horizon. The appropriateness of the choice is enhanced by the fact that the apical system, on the structure of which Pomel based the genus, is best known in this one of the three species.

Some discrepancy in the spelling of the name of the genotype has occurred, owing to the printing of no fewer than three different versions by Wright at the time of its first appearance. Of these, *macrostomus* (Wright, Pal. Soc., *Ool. Ech.*, p. 424), although the first in order, may be dismissed as barbarous and probably accidental. There is little to choose between the two other renderings, *macrostoma* and *megastoma*, in respect of their etymology, but since the former accompanies the description of the species, and is several times repeated (loc. cit., pp. 463, 464), it has a technical advantage over the latter, which is employed only on the legend to the plate. Moreover, the name *macrostoma* has been adopted by authors generally (with the exception of Pomel), and so may be stereotyped as the correct designation of the species.

The genus *Plesiechinus* was either rejected or ignored by writers from the time of its publication until 1912, when I provisionally adopted it (Geol. Mag.) on grounds similar to those that caused its proposal. Later in the same year (Proc. Zool. Soc.) I rejected the name on systematic considerations, but retained the division under the name of *Pygaster* s.str. This was due to a misconception of the meaning of the name *P. semisulcatus* (the genotype of *Pygaster*, Agass.). Having recognized that the *P. semisulcatus* of authors later than 1850 is entirely different from that of previous writers, and belongs to a different genus, I have been compelled to retain the generic name *Pygaster* for the former type, so that the name *Plesiechinus* can be revived for the latter.

Some further apology for the reinstatement of a genus rejected by so many authorities seems necessary. The original diagnosis given by Pomel is as follows: "Ce sont des *Pygaster* dont l'apex est formé de quatre génitales peu inégales, disposées en demi-cercle, ainsi que les ocellaires postérieures, et formant le cadre supérieur du périprocte, qui est oblong et très vaste." The only criticism that can be made concerns the final words. The periproct in *P. macrostoma* is certainly large, but not so extensive, in proportion, as it is in many species of the true *Pygaster*. The reference to its shape, and the description of the apical system, hold good. As will be found in the detailed analyses that will appear in later papers of this series, there are many other features in which the species of *Plesiechinus* resemble one another and differ from those of the other Pygasterinæ, but I feel convinced that, in this case, the characters of the apical system are alone sufficient to render the genus valid. The most obvious, as well as most fundamental, difference between Regular and Irregular Echinoids lies in the relation between the periproct and the apical system. Among the Pygasteridæ we have the history of their separation gradually revealed. The first stage is marked by the destruction of the posterior genital plate, and the splaying out of the apical system to give passage to the retreating periproct. Later stages are concerned with the closing in and readjustment of the plates of the system when the aperture has been sufficiently withdrawn. *Plesiechinus*, as here defined, comprises all species that show the first stage of periproct-migration; the other Pygasteridæ include representatives of the later conditions. There are thus sound phylogenetic reasons for the genus, which are rendered the more secure when it is seen that all the species referable to it with certainty are the earliest members of the family. On both morphological and stratigraphical evidence we find in *Plesiechinus* "le type le plus rapproché des globiformes" (Pomel).

Pygaster reynesi, Desor, and *Clypeus ornatus*, Buckman, are two well-defined species of *Plesiechinus*, in addition to the genotype, *P. macrostoma*, Wright.

5. Summary.

The following list includes all the changes rendered immediately necessary as a result of the previous discussion:—

Pygaster, Agass., 1836 (incl. *Megapygus*, Hawkins, 1912).

Type, *Clypeus semisulcatus*, Phill. Corallian (incl. *Pygaster umbrella, pars*, auct.) (non *Pygaster semisulcatus*, auct.).

Plesiechinus, Pomel, 1883 (incl. *Pygaster* sens. str., Hawkins, 1912).

Type, *Pygaster macrostoma*, Wright. Bathonian.

Generally speaking, *Pygaster* is a Middle and Upper Oolitic group, and *Plesiechinus* is restricted to the Lias and Lower Oolite.

VI.—The Genotypes of certain Polyzoan Genera.

By W. D. Lang, M.A., F.G.S.

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IN working through the literature of Cretaceous Cribrimorph Polyzoa, it has been found necessary to determine the significance of the genera under which the different Cretaceous species have been placed by various authors, and, consequently, the genotypes of these genera. In several cases where a genus has been founded upon more than one species, apparently no subsequent author has definitely chosen a genolectotype from the several genosyntypes at his disposal; it has, therefore, seemed desirable to publish a list of certain genera under which various authors have placed Cretaceous Cribrimorph forms, namely those of which the genotype is or has been in doubt. It is hoped thus to simplify the work of future authors and to reduce to less confusion the somewhat chaotic use of certain names.

I wish to record my obligations to my colleague, Dr. S. F. Harmer, for much help and valuable criticism; but it should be noted that the conclusions arrived at do not always coincide with his opinions.

Antropora, Lang, 1916, pp. 86, 91; genotype, *A. cavernosa* Lang, 1916, pp. 91, 92; *Antropora* is preoccupied by Norman, 1903 [2], p. 87; genotype, *Membranipora granulifera*, Hincks, 1880 [2], p. 72, pl. ix, fig. 4; Recent, Madeira. *Cœlopora* is proposed for *Antropora* Lang, non Norman. I am obliged to Dr. S. F. Harmer for pointing out this error of mine, as well as another in the case of *Corymbopora*.

Barroisina, Jullien, 1886, p. 605; genotype, *Reptescharipora elegantula* von Hagenow sp., Beissel, 1865, pp. 60, 11, 90, pl. vii, fig. 82; non *Cellepora* (*Escharina*) *elegantula*, Hag.; von Hagenow, 1851, p. 90, pl. x, fig. 13.

Cellepora, Linnæus, 1767, p. 1285; genosyntypes, six Recent species, of which *Cellepora pumicosa* Linnæus is taken by Hincks (1880 [1], p. 398) as the genolectotype.

Cœlopora, n.gen.; genotype, *Antropora cavernosa* Lang, 1916, pp. 91 and 92; see *Antropora*.

Corymbopora, Lang, 1916, pp. 382, 385; genotype, *C. religata* Lang, 1916, p. 385. *Corymbopora* is preoccupied by Michelin, 1846, p. 213; genotype *C. menardi* Michelin, 1846, p. 213, pl. liii, fig. 10; see *Corymboporella*.

Corymboporella, n.gen.; genotype, *Corymbopora religata* Lang, 1916, p. 385.

Cribrilina, Gray, 1848, p. 116; genotype, *Lepralia punctata*, Hassall, 1841, p. 368, pl. ix, fig. 7; *Cribrilina* is so frequently used for Cretaceous Cribrimorphs, without further explanation, that it is as well to emphasize the genotype.

Dermatopora, von Hagenow, 1851, pp. 87, 98; genosyntypes, *Cellepora* (*Dermatopora*) *monilifera* von Hagenow, 1851, p. 98, pl. xi, fig. 1; *Cellepora lyra* von Hagenow, 1839, p. 269, pl. iv, fig. 8; *Cellepora ornata*, Goldfuss, 1826, pp. 26, 248, pl. ix, fig. 1; *Cellepora* (*Dermatopora*) *faujasi* von Hagenow, 1851, p. 99,

pl. x, fig. 19; genolectotype (here chosen), *Cellepora* (*Dermatopora*) *monilifera* von Hagenow, 1851, p. 98, pl. xi, fig. 1.

Discopora, Lamarck, 1816, p. 164; genosyntypes, nine Recent species, of which Gray (1848, p. 126) has chosen *Cellepora verrucosa* Esper, 1790, p. 239, pl. ii, figs. 1 and 2 (= *Tubipora verrucosa* Linnæus, 1758, p. 789) as genolectotype. At the same time, Gray explains that the *Cellepora verrucosa* of Esper is not the *C. verrucosa* of Lamarck. Until the identity of *Cellepora verrucosa* is determined, the interpretation of *Discopora* must remain uncertain.

Distansescharella, d'Orbigny, 1853, p. 463; genosyntypes, *Cellepora familiaris* von Hagenow, 1839, p. 274; *Escharina inflata*, Römer, 1840, p. 14, pl. v, fig. 5; *Escharina radiata* Reuss, 1846, p. 68, pl. xv, fig. 19; genolectotype, *Cellepora familiaris* von Hagenow, 1839, p. 274; see Lang, 1916, p. 387.

Eschara, Linnæus, 1758, p. 804; genosyntypes, *E. foliacea* Linnæus, 1758, p. 804; *E. fistulosa* Linnæus, 1758, p. 804; *E. fragilis* Linnæus, 1758, p. 805; *E. divaricata* Linnæus, 1758, p. 805; *E. verticillata* Linnæus, 1758, p. 805; genolectotype, *E. foliacea*, Linnæus, 1758, p. 804, implicitly chosen by Linnæus (1761, p. 539), who, in establishing the name *Flustra* to supplant the name *Eschara*—"nomen *Escharæ* in *Flustram* transmutavi, cum prius Morbi homonymon"—mentions three species of *Flustra*, of which the first two are *F. foliacea* and *F. fistulosa*, and the other does not occur among the genosyntypes of *Eschara*; again, in 1767, pp. 1300, 1301, he gives six species of *Flustra*, of which the first, *F. foliacea*, is the only genosyntype of *Eschara*; it seems clear then that *E. foliacea* was in Linnæus' mind as typical when *Eschara* was founded; besides, *F. foliacea* is commonly recognized as the genolectotype of *Flustra*. See also under *Flustra*.

Escharella, Gray, 1848, p. 125; genosyntypes, *Berenicea immersa* Fleming, 1828, p. 533; *Lepralia violacea* Johnston, 1847, p. 325, pl. lvii, fig. 9; *Lepralia variolosa* Johnston, 1838, p. 278, pl. xxxiv, fig. 4; all Recent; genolectotype, *Berenicea immersa* Fleming, 1828, p. 533, selected by Norman, 1903[2], p. 117.

Escharina, Edwards in Lamarck, 1836, pp. 218, 230; genotype, *E. vulgaris* Moll, 1803, p. 55.

Escharipora, d'Orbigny, 1852, p. 220; genosyntypes, seventeen Senonian species, of which *E. inornata* d'Orbigny, 1851, pl. 686, figs. 17–19, 1852, p. 230, is here chosen as the genolectotype.

Escharoides, Edwards in Lamarck, 1836, pp. 218, 259; genosyntypes, eleven Recent and eight fossil species, of which Verrill, 1879, p. 149, selected *Cellepora coccinea* Abildgaard, 1806, p. 30, pl. cxlvi, figs. 1 and 2, as genolectotype.

Flustra, Linnæus, 1761, p. 539; genosyntypes, *F. foliacea*, Linnæus, 1761, p. 539 (= *Eschara foliacea* Linnæus, 1758, p. 804); *F. fistulosa* Linnæus, 1761, p. 539 (= *Eschara fistulosa* Linnæus, 1758, p. 804); *F. pilosa* Linnæus, 1761, p. 539. In establishing the name *Flustra*, however, Linnæus states positively that he is replacing the name *Eschara*—"nomen *Escharæ* in *Flustram*

transmutavi"—by *Flustra*. Therefore *Eschara* and *Flustra* are by definition, synonyms, and, since Linnæus himself had no power to supplant one of his own names, *Eschara* must stand and *Flustra* fall. Since, however, the name *Flustra* is invariably used for *F. foliacea*, the genolectotype of this genus and of *Eschara* (see under *Eschara*), while *Eschara* is used variously, it would be desirable, if possible, to standardise the name *Flustra* and delete *Eschara* from zoological nomenclature.

Hippothoida, Vine, 1893, p. 316; *Hippothoida brevis*, Reuss, is written for *Hippothoa brevis* Reuss; it is clear that Vine did not intend thereby to found a new genus, but that *Hippothoida* is a *lapsus* for *Hippothoa*.

Lagodiopsis, Marsson, 1887, p. 99; genotype, *Multescharipora francqana* d'Orbigny, 1852, pl. 734, figs. 6–8, 1853, p. 497; this species is generally considered congeneric with *Murinopsia* Jullien, 1886, p. 608, with the genotype *Semiescharipora galeata* Beissel, 1865, p. 55, pl. vi figs. 70–75, pl. vii, fig. 76; in this connection it may be observed that Marsson mentions a second species of *Lagodiopsis*, namely *Cellepora pinguis* von Hagenow, 1851, p. 88, pl. x, fig. 15, a form probably congeneric with *Cribrilina triceps* Marsson, 1887, p. 98, pl. x, fig. 12, and therefore a *Tricephalopora*; but it seems that Marsson meant to found *Lagodiopsis* upon *Multescharipora francqana* d'Orbigny and that this species therefore must be regarded as the genotype.

Lekythoglena, Marsson, 1887, p. 90; genosyntypes, *L. ampullacea* Marsson, 1887, p. 91, pl. ix, fig. 7; *L. effigurata* Marsson, 1887, p. 91, pl. ix, fig. 8; genolectotype, *L. ampullacea*, Marsson, 1887, p. 91, pl. ix, fig. 7, see Lang, 1916, p. 390.

Lepralia, Johnston, 1838, p. 277; genosyntypes, seven Recent species of which Norman, 1903[2], pp. 99, 100, has chosen *L. nitida* Johnson (i.e. *Berenicea nitida* Fleming, 1828, p. 533, non *Cellepora nitida* Fabricius) as the genolectotype. While accepting Norman's solution of a difficult problem, I must admit that it is arguable with equal propriety that *Lepralia* is synonymous with *Escharoides*, Edwards. But, where two solutions are equally tenable, and one has already been deliberately chosen, not to follow this rule would be contrary.

Membranipora, Blainville, 1830, p. 411; genosyntypes, six Recent and five fossil species, of which the genolectotype is *Flustra membranacea* Linnæus, 1767, p. 1301; see Norman, 1903[1], p. 585.

Membraniporella, Smitt, 1873, p. 10; genotype, *Lepralia nitida*, auctt., but with reference to Smitt, 1868, pp. 306, 401, on the former page of which it is clear that *Lepralia nitida* Johnston (1838, p. 277, pl. xxxiv, fig. 7) is meant. This species is the genolectotype of *Lepralia*—see under *Lepralia*—of which *Membraniporella* is thus a synonym.

Phractopora, Lang, 1916, p. 89; genotype, *P. constrata* Lang, 1916, p. 89. *Phractopora* is preoccupied by Hall, 1883, p. 154; genotype, *P. cristata* Hall, 1883, p. 154. I am indebted to Dr. R. S. Bassler for pointing this out to me.

Phractoporella, n.gen. ; genotype, *Phractopora constrata* Lang, 1916, p. 89.

Porina, d'Orbigny, 1853, p. 432 ; genosyntypes, thirteen species; of which two are Recent, seven Tertiary and four Cretaceous; of these, the Recent *Eschara gracilis* Lamarck, 1816, p. 176, is here chosen as the genolectotype.

Prosoporella, Marsson, 1887, p. 100; genotype, *Semieschariporа cornuta* Beissel, 1865, p. 58, pl. vii, figs. 77–81 ; this species is the genotype of *Decurtaria* Jullien, 1886, p. 606, which thus has the priority over *Prosoporella.*

Reptescharella, d'Orbigny, 1853, p. 464 ; genosyntypes, six Recent, three Tertiary and twelve Cretaceous species, of which *Eschara lorieri* d'Orbigny, 1851, legend to pl. 604, figs. 11–12 (*Reptescharella lorieri* d'Orbigny, 1853, p. 466) is here chosen as genolectotype.

Reptescharellina, d'Orbigny, 1853, p. 451 ; genosyntypes, twelve Recent, twelve Tertiary and five Cretaceous species, of which *R. horrida* d'Orbigny, 1852, pl. 715, figs. 7–9, 1853, p. 456, from the Senonian of Tours, Vendôme and Royan, is here chosen as genolectotype.

Reptescharinella, d'Orbigny, 1853, p. 428; genosyntypes, two Recent, one Tertiary and eight Cretaceous species, of which *Cellepora* (*Discopora*) *subgranulata* von Hagenow, 1851, p. 91, pl. xi, fig. 15, from the Maastrichtian of Maastricht, is here chosen as genolectotype.

Reptescharipora, d'Orbigny, 1853, p. 489 ; genosyntypes, one Recent, two Tertiary and eleven Cretaceous species, of which *R. meudonensis* d'Orbigny, 1852, pl. 719, figs. 17–19, 1853, p. 491, is here chosen as genolectotype.

Reptocelleporaria, d'Orbigny, 1852[2], p. 679 [name only], 1853, p. 421 ; genosyntypes, three Recent, ten Tertiary and two Cretaceous species, of which *R. cretacea* d'Orbigny, 1852, pl. 713, figs. 17–18, 1853, p. 423, from the Senonian of Meudon, is here chosen as genolectotype.

Reptoporella, d'Orbigny, 1853, p. 474; genotype, *R. regularis* d'Orbigny, 1852, pl. 717, figs. 6–7, 1853, p. 475; this species is possibly congeneric with *Leptocheilopora tenuilabrosa* Lang, 1916, pp. 396–7, and, if so, the genus *Leptocheilopora* Lang, 1916, p. 396, must give place to *Reptoporella.*

Rhiniopora, Lang, 1916, pp. 93, 96 ; genosyntypes, ten Cretaceous species, of which *R. aspera* Lang, 1916, pp. 96, 97, is here chosen as genolectotype.

Semieschara, d'Orbigny, 1852, p. 364; genosyntypes, four Recent, two Tertiary and nineteen Cretaceous species, of which *S. flabellata* d'Orbigny, 1852, p. 367, pl. 708, figs. 1–4, is here chosen as genolectotype.

Semieschariporа, d'Orbigny, 1853, p. 479; genosyntypes, one Tertiary and thirteen Cretaceous species, of which *S. complanata* d'Orbigny, 1852, pl. 718, figs. 17–20, 1853, p. 484, is here chosen as the genolectotype.

Steginopora, d'Orbigny, 1853, p. 499 ; genosyntypes, *S. irregularis*

d'Orbigny, 1852, pl. 720, figs. 16–19, 1853, p. 500; *S. ornata* d'Orbigny, 1852, pl. 721, figs. 1–4, 1853, p. 501; *S. aculeata* d'Orbigny, 1852, pl. 721, figs. 5–8, 1853, p. 502; *S. pulchella* d'Orbigny, 1852, pl. 721, figs. 9–12, 1853, p. 503; genolectotype, *S. ornata* d'Orbigny, 1852, pl. 721, figs. 1–4, 1853, p. 501; see Lang, 1916, p. 100.

Thoracophora, Jullien, 1886, p. 610; genotype, *Escharina horrida* d'Orbigny, 1850, p. 264, which is the genotype of *Disteginopora*; *Thoracophora* Jullien is, therefore, a synonym of *Disteginopora* d'Orbigny, 1852, p. 235. N.B. Dr. Harmer has pointed out to me that in the Zoological Record, vol. xxiii, 'Polyzoa,' p. 12, the recorder—Hoyle—states that *Thoracophora* is preoccupied.

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REVIEWS.

I.—Irregularities in the Post-Glacial Uplift of Norway.

BY measuring the present heights of old sea-beaches the Scandinavian geologists have been able to work out the salient features of the tilt their country has acquired during its rise in Post-Glacial times. To demonstrate the amount and character of the uplift since any particular period, it is first necessary to distinguish the beach formed at that period, which is itself often a matter of considerable difficulty owing to the presence of other beaches, and then to measure the various levels at which it now occurs. These determinations are marked on the map, and from them lines—the isobases—are drawn such that for any points on one line the present height of the beach is the same, the lines being drawn for convenient and constant differences of level. Thus the character and degree of uplift are seen at a glance, the isobases lying closer together where the tilt is greater and farther apart where it is less. These maps are usually drawn on a small scale, and the isobases appear as smooth parallel lines with a fairly constant distance between, indicating that the country has yielded to the forces of upheaval as one homogeneous mass.

Recently, by determining the heights of old beaches with great care and plotting on a large scale map, Holmsen has found that the isobases in some districts swing right out of their normal course, proving minute but unmistakable inequalities of uplift.[1] The beaches of former ice-dammed inland lakes are better adapted for this accurate work than those marking ancient sea-shores in the coastal regions, because they are in a more complete state of preservation. This is to be expected when it is remembered that the sea-level sank little by little, so that there is not only a risk of confusing the various coast beaches, but they have often been mutilated and sometimes obliterated by the waves of the gradually falling sea surface. As the glacial lakes were suddenly drained, no such force has operated to mar their beaches, the levels of which can be determined with great accuracy.

[1] "Om Strandlinjernes Fald omkring Gabbroomraader": Gunnar Holmsen, Norsk Geologisk Tidsskrift, Bd. iv, H. i, pp. 7–20, 1916.

The northern part of the osterdal is the site of an old ice-dammed lake and two beaches are present, one being about 55 m. above the other. Holmsen gives a map of the district with the isobases of the lower beach drawn for every 5 m. difference in level. A general tilt away from the ice-shed, which lay to the south-east, is revealed. The isobases run regularly across the mountainous country of granite and altered sedimentaries, but are turned aside by a gabbro mountain. The plane of the former lake-level dips, on the north-west side of the gabbro, at a rate of 0·85 to 1·63 metres per kilometre, being greater than the average gradient of the district, which is 0·70 m. per km., whilst on the opposite side the normal north-west dip is lessened and even reversed. This can be explained by postulating a greater uplift of the gabbro than that of the whole district, and this view receives additional support from a consideration of the vertical relations of the two beaches, which are not quite parallel to each other. Compared with the lower beach, the upper one exhibits higher levels the nearer it is situated to the gabbro mountain. Near the gabbro the upper beach is 57·9 m. above the lower, but only 54·5 m. some distance away, showing that the extra upheaval of the gabbro was in progress before the lower and younger beach was formed, as well as afterwards.

Although for the reasons pointed out above the evidence is not so detailed, the present heights of two raised sea-beaches in North Norway, between Tromsø and Hammerfest, mapped by Helland, show the great masses of basic eruptive rocks to be standing higher relatively to the surrounding country than they did formerly. It is known that slight irregularities of uplift can sometimes be referred to irregularities in surface relief, but this is not the determining factor in the cases discussed by Holmsen, where, significantly, the specially raised districts are all built up of heavy basic eruptive rocks. The phenomena would seem to be connected with the greater density of the masses affected, although it is not at all clear how this has operated. One cannot help admiring the precision of this work, whereby such minute variations in the uplift of the land have been discovered and measured.

L. Hawkes.

II.—Notes on the Geology of Chitral, Gilgit, and the Pamirs. By H. H. Hayden, C.I.E., F.R.S., Director Geological Survey of India. Rec. Geol. Surv. India, vol. xlv, pt. iv, pp. 271–335, 1915.

In this part is contained an interesting account of a preliminary geological reconnaisance through Chitral, the Gilgit district, and the Pamirs. In the outer mountains of Dir and Swat there is a belt of igneous and metamorphic rocks, which is probably the equivalent of the igneous and metamorphic series which occurs below Jelalabad on the Kabul River. Between Dir and Chitral granite is found, but north of the Laorai Pass this gives place to a series of sedimentary rocks, which comprise members at least as old as the Devonian and as young as the Cretaceous. This series extends across from Chitral to the districts of Yasin and Hunza. To the north of this series is found

a belt of slates, which extends from the Wakham (Nicholas) range to the Taghdumbash Pamir in Chinese Turkestan, and this is followed further north by a calcareous series known as the Pamir Limestone. This is the most prominent rock of the Russian Pamirs, and includes rocks of Triassic and Jurassic age. North of the Pamir Limestone comes a group of slates, probably identical with those of Wakham, but associated with shales and limestone containing Upper Devonian fossils. Beyond this belt, in the valley of the Kizil-su, there is a typical development of the Ferghana series. The strike of all these rocks, both in Chitral and the Pamirs, follows the general direction of the ranges. In Chitral it changes from S.W.–N.E. in Western Chitral to W.–E. in the Yasin district, and no doubt turns down to the south farther east. In the Pamirs the strike in the central parallel ranges is W.–E., and this swings round to the S.W. at the west end and to the S.E. at the east end, following the general lines of the great bay in the Himalayan folds, which contains the North-West Provinces of India. These observations show that the Chitral Mountains and the Pamirs are true tectonic features.

Up to the present the Pamirs have always been represented on maps as being bounded on the east by two parallel ranges running north and south, which were assumed by Suess and Fütterer to be true tectonic features, and to indicate a great irregularity in the trend of the chief structural lines of this part of Asia. This, however, is not the case. In both these ranges the strike is fairly constantly W.–E., at right angles to the trend of the range, and only occasionally turns to the N.W.–S.E. The western or Sarikol range may then be regarded as "the eroded scarp of the Pamir plateau", while the eastern or Kashgar range probably owes its origin to the elevation and induration of the strata round the granite masses which form the peaks of Kungur and Mustagh-ata. The strike probably changes round these granites, but not more than is usually the case in the neighbourhood of large intrusions; so that the range is only partly tectonic, and offers no evidence in favour of the theories of Suess and Fütterer.

W. H. W.

III.—Platiniferous Deposits of Spain and Russia. Etude comparée des Gites Platinefère de la Sierra de Ronda et de l'Oural. Par Louis Duparc et Augustin Grosset. Mém. Soc. Phys. Hist. Nat. Genève, vol. xxxviii, pp. 253–290, 1916, avec 7 figures, 1 carte, et 4 planches.

PERIDOTITES and serpentines occur on an extensive scale on the southern slopes of the Sierra de Ronda, between Malaga and Estopona, and M. Orueta, who has recently mapped the district on a scale of 1 : 100,000, impressed by the resemblance of the rocks to those which are now recognized as the source of platinum in the Urals, examined the alluvia of several rivers draining the district and found platinum in them.[1]

[1] In a note published in the Comptes Rendus Acad. Sci. Paris, tom. 162, p. 45, 1916, M. Orueta states that 50 "sondages" in the alluvial deposits yielded on the average 3 grams per cubic metre, with a maximum of 28 grams.

In consequence of this discovery the two authors of the memoir under review, one of whom, M. Duparc, has made a special study of the Russian deposits, visited the Spanish locality in order to compare the modes of occurrence in the two countries. Their work was greatly facilitated by M. Orueta, who supplied them with a copy of his unpublished map.

The memoir begins with a description of the topography, geology, and petrography of that portion of the Sierra de Ronda in which the platiniferous deposits occur. The principal constituents of the ultrabasic rocks are spinels, rhombic and monoclinic pyroxenes, and olivine. These constituents are mixed in varying proportions. The most common variety is composed of brown spinel, olivine, and a rhombic pyroxene (hartzburgite). Next to this comes a variety containing a monoclinic pyroxene in addition to the above-mentioned constituents (lherzolite). A third type corresponds to dunite. But all these varieties shade into each other and all are liable to serpentinization. The authors compare the structure of those areas in which dunite is found to a sponge; dunite filling the hollows and the other varieties forming the network. They consider that the peridotites were intruded into the surrounding gneissose and more or less metamorphosed sedimentary rocks after the Cambrian period and before the formation of a conglomerate, which is either of Permian or Triassic age; but no satisfactory evidence of the reference of any of the surrounding sedimentary rocks to the Cambrian period is given.

M. Orueta supplied the authors with a few small grains of platinum. Two varieties were noticed. One shows under the microscope polygonal depressions which are precisely similar to those observed on grains derived from pyroxenic rocks in the Urals. They possess a yellowish bronzy lustre and have generally been much rounded. The other variety, also rounded, appears absolutely black. Heated in a borax bead the patina disappears, and the borax on cooling assumes a faint greenish tint. The platinum acquires a silvery metallic appearance. The removal of the patina discloses the presence of minute hollows filled with a black mineral which the authors believe to be chromite. Precisely similar grains are found associated with chromite in the Urals. Microchemical tests revealed the presence of osmium, platinum, palladium, copper, iron, and nickel. The largest specimen examined weighed ·02338 gram; but M. Orueta has obtained much larger ones and also a small nugget weighing 2 grams.

The authors then describe two or three of the typical Russian occurrences, laying special emphasis on the differences between the two localities. In the Urals dunite is developed on a much more extensive scale. It forms large more or less elliptical masses surrounded by a fringe of pyroxenic rocks which are, in their turn, surrounded by gabbro. In the Sierra de Ronda the dominant peridotite contains a rhombic pyroxene, and the mass is directly surrounded by metamorphic rocks into which the peridotites have been intruded. Dunites occur in both localities, but in the Urals they are, as a rule, sharply separated from the pyroxenites, whereas

in the Sierra de Ronda they pass gradually into peridotites with pyroxene. The alluvial deposits also present important differences.

The memoir concludes with the description of the peridotites of Khrebet-Salatin, in the northern part of the Urals, which differ in their mode of occurrence from those of the classical platiniferous localities and resemble those of the Sierra de Ronda. Platinum has been found in the alluvia of rivers draining Khrebet-Salatin, but no satisfactory results from the economic point of view have as yet been obtained.

Although the result of the comparison of the typical platiniferous localities of the Urals with the Sierra de Ronda is not exactly encouraging, it is to be hoped that M. Orueta's interesting discovery will be followed up, and that it will lead to an important addition to the world's supply of platinum.

IV.—Geology and Petrography of the Urals. Recherches Géologiques et Pétrographiques sur l'Oural du Nord : le Bassin des Rivières Wagran et Kakwa. Par Louis Duparc et Margarite Tikanowitch. Mém. Soc. Phys. Hist. Nat. Genève; Quatrième Mémoire, pp. 69–168, avec 11 figures et 2 planches.

THIS memoir consists mainly of detailed petrographical descriptions of rocks collected during explorations made in 1903. The district lies to the east of the main watershed of the Urals and is traversed by lat. 60° N. No detailed map exists, and the country, which is largely covered with forest, is practically uninhabited.

Passing eastward from the line which separates the rivers of Europe from those of Asia one traverses a zone of quartzose schists and quartzites, the latter forming anticlinals in the former. This is succeeded by a zone of hornblende rocks, more or less schistose, some of which appear to have belonged originally to the diabase family. On the right bank of the Wagran green quartzose schists are followed by plutonic rocks, consisting of gabbro-diorites, quartz-diorites, and granites with plagioclase. Normal fresh gabbros are also present on an extensive scale, but pyroxenites and dunites are comparatively rare, and when they do occur the pyroxenites do not form a zone round the dunites as they do in other parts of the Urals. The dyke rocks include beerbachites with hornblende, diorite-porphyrites, and a peculiar rock, intrusive in dunite, to which the authors apply the name of gladkaite. This is a fine-grained rock composed of apatite, magnetite, biotite, muscovite, hornblende, epidote, quartz, and plagioclase felspars, which vary in composition from labradorite to oligoclase-andesine, andesine being the dominant variety.

The petrographical descriptions, which make up more than two-thirds of the memoir, are full of details as to the birefringence and other optical characters of the minerals. Numerous chemical analyses are given, but they are not up to the standard of the best modern work, and the name of the analyst is not mentioned.

V.—A Lower Devonian Fauna of the United States.

The Fauna of the Chapman Sandstone of Maine, including Descriptions of some Related Species from the Moose River Sandstone. By Henry Shaler Williams, assisted by Carpel Leventhal Breger. Professional Paper 89, Department of the Interior, United States Geological Survey (George Otis Smith, Director). pp. 347, with 27 plates. 1916.

THE principal author of this monograph, Professor H. S. Williams, has for long been an authority on the Palæozoic rocks and fossils of Maine, in the endeavour to trace a relationship between the well-known Upper Palæozoic of Europe and that of the interior of the North American Continent. In the volume before us we are introduced to an extensive fauna belonging to the Chapman Sandstone formation of Maine, which is regarded as possessing an intermediate facies and so "linking together the faunas of New York and those of the Tilestone, or terminal Silurian, of Great Britain". In the study of British collections it was found that hardly any of the species were actually identical with those of the Chapman fauna, although many showed marked affinities. For purposes of comparison, the closely related fauna of the Moose River Sandstone exposed in Central and Northern Maine is also considered, but not exhaustively, only a few new species being now described. Some further forms from typical regions of Aroostook County, Maine, are also included. The major part of the memoir is taken up with minute descriptions of the species which, according to Professor Williams, has been mostly the work of his assistant, Mr. C. L. Breger. More than a hundred species are discussed belonging to the groups Cephalopoda, Gastropoda, Pelecypoda, Trilobita, Ostracoda, and some Plant remains (*? Psilophyton*), as well as a fish fragment (*Asterolepis clarkei*, Eastman), the Brachiopods and Pelecypods being, however, the more abundant organisms. Some fifty or more new species are established, together with the following new genera and sub-genera—**Pelecypoda**: Preavicula type = *Megambonia oblonga*, Hall; Sphenotomorpha type = *S. rigidula*, n.sp.; Grammysioidea type = *G. princiana*, n.sp.; Nuculoidea type = *Nucula opima*, Hall. **Brachiopoda**: Antispirifer type = *A. harroldi*, n.sp. **Ostracoda**: Zygobeyrichia type = *Z. apicalis*, n.sp., and including also *Beyrichia devonica* of Jones & Woodward, from the Lower Devonian of England.

The fauna of the Chapman Sandstone is regarded as of true Lower Devonian age, with affinities to the Helderbergian fauna of New York, but characterized by more numerous European types than the typical Helderbergian. Compared with Europe, the Chapman fauna shows affinities with the Lower Devonian, particularly that portion of it below the Upper Coblenzian. It is, moreover, said to be a later fauna than the Tilestone or Downtonian of England, or the terminal marine fauna of Arisaig, Nova Scotia, being besides recognized as of earlier age than that of the Moose River Sandstone, which may be correlated with the Oriskany Sandstone of New York and the York River (Gaspe Sandstone) of Gaspe Peninsula.

In a footnote on p. 27 the date of *Leptæna explanata* by J. de C.

Sowerby is called in question, a species from the Rhenish Lower Devonian described and figured in an "Appendix" to a memoir by Archiac & Verneuil on that subject published in the Trans. Geol. Soc., London, vol. vi, pt. ii, p. 409, pl. xxxviii, fig. 15, 1842. On p. 410, and immediately following Sowerby's Appendix, is a concluding note by Archiac & Verneuil, dated September 10, 1842, which would indicate that this part of the Transactions was issued fairly late in 1842. The reviewer's own copy of this work has the original wrappers preserved, so that there is no doubt as to 1842 being the year of publication of this particular part.

The European species is tentatively regarded as being synonymous with Conrad's *Strophomena perplana*, which, according to the present memoir, "is known to have been published early in 1842." It would follow, therefore, that if this synonymy is adopted Conrad's name should be preferred, as Sowerby's *explanata* was not established until a much later period of that year. Although we consider that much of the descriptive work might have been more briefly stated, and the synonymic lists reduced in many instances, the memoir is, doubtless, a great contribution to geological science, and we heartily commend it to all interested in Devonian faunas.

R. B. N.

VI.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1915.

On the North Wales border work was continued to the southern termination of the Denbighshire coalfield, and the mapping of the neighbourhood of Shrewsbury was commenced. In Warwickshire the surveying of the Upper Red Coal-measures was completed as far south as Coventry, and this has rendered possible a revision of the estimates of the depth and resources of the concealed coalfield. Thirty-eight square miles may now be added to the area, as estimated by the last Coal Commission, within which the coals probably lie between 2,000 and 3,000 feet below the surface.

In Staffordshire an area of four square miles, hitherto supposed to be overspread by Bunter, has been found to consist mainly of the Upper Coal-measures supporting small outliers of Bunter Sandstone.

In Scotland field work was carried on in the basaltic plateau of Mull, near Tobermory, in the Central Highlands, near Dalwhinnie, and in the coalfields of Ayrshire, Lanarkshire, and Renfrewshire. But the carrying out of the original plans was much interfered with by special investigations connected directly or indirectly with the War.

The report on the chemical researches contains full analyses of eighteen igneous rocks, two from Lundy Island and the remainder from Mull. It also contains an account of some interesting investigations on clays made in the Government Laboratory, Clement's Inn Passage. "Rational" and "Ultimate" analyses of seven clays were made, and a comparison of the results shows "that the felspar found in the 'Rational' analysis is in all cases very much lower than that calculated on the assumption that all the sodium and potassium oxide

is present as felspar. The values for quartz are very much closer and in five cases are in satisfactory agreement".

The "Summary" also contains appendices dealing with (1) a deep boring for coal near Little Missenden, Bucks, and (2) a Catalogue of Types and Figured Specimens of British Cretaceous Gasteropoda preserved in the Museum of Practical Geology.

VII.—Economic Geology. By Heinrich Ries, A.M., Ph.D., Professor of Geology at Cornell University. Fourth edition, thoroughly revised and enlarged. pp. xx + 856, 6″ by 9″, with 291 figures and 75 plates. New York, John Wiley & Sons; London, Chapman & Hall, Ltd. 1916. $4·00 net.

THIS is a revised and enlarged edition of Professor Ries' well established book, written especially for American teachers and students, on Economic Geology. Like the previous editions it gives concise descriptions of the composition, mode of occurrence and origin of the economically valuable rocks and minerals of the United States, to which have now been added descriptions of the more important Canadian deposits, and brief references to those of other countries. The latest available statistics of production have been included and each section is accompanied by a valuable bibliography, dealing especially with North American occurrences. The book has been brought up-to-date, and is well illustrated by sections, maps, and photographs.

VIII.—Origin of the Zinc and Lead Deposits of the Joplin Region. By C. E. Sienbenthal. Bulletin 606 United States Geological Survey. Washington, Government Printing Office, 1915. pp. 283, with 9 plates and 16 figures in the text.

FOR some dozen years the author was engaged in studying the famous zinc and lead deposits of the Joplin region. Besides their great economic importance these deposits have long been of intense interest to students of ore deposition, because they form a conspicuous example of the occurrence of sulphide ores in a region where apparently no plutonic or volcanic activities can have played a part in their genesis. Mr. Sienbenthal has carefully considered and tested the numerous theories that have been put forward from time to time by other observers, and has come to the conclusion that the ores were segregated by artesian—circulating alkaline—saline sulphuretted waters from zinc and lead minerals disseminated in the Cambrian and Ordovician limestones of the Ozark uplift, which is a low asymmetric dome, rudely elliptical in outline, lying in southern Missouri, northern Arkansas, south-eastern Kansas, and north-eastern Oklahoma. The great mass of the ores appear to have been conveyed as bicarbonates, and to have been precipitated as soon as the water bearing them reached the surface and gave up the carbonic acid dissolved in it. The data upon which his conclusions are based are very fully set forth. The memoir is one that should be studied by all those interested in the question of the genesis of ore deposits.

IX.—Preliminary Report on the Mineral Production of Canada during the calendar year 1915. By John McLeish. Ottawa, Government Printing Bureau, 1916. pp. 28.

THE report reveals very clearly how greatly the mineral industry was stimulated by the War, the demand for the metals copper, lead, nickel, and zinc being specially great. The steel furnaces were worked to their utmost capacity. Further, the development of smelting and refining operations has been greatly stimulated, since it was desirable that for such necessary adjuncts the country should not be dependent on even a friendly neutral country. The production of copper increased 72, of lead 56, and nickel 49½ per cent in value. Canada produced during the year nearly 3 million dollars worth of gold.

REPORTS AND PROCEEDINGS.

Geological Society of London.

1. *February* 7, 1917.—Dr. Alfred Harker, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Trias of New Zealand." By Charles Taylor Trechmann, M.Sc., F.G.S.

The fossiliferous Triassic rocks of New Zealand have been wholly or in part at different times attributed by the geologists of that Dominion to a Devonian, Permian, Permo-Carboniferous, Lower, Middle, or Upper Triassic, or Trias–Jura age. A review of the previous research on these rocks and of their correlation and nomenclature is given. They are quite distinct from the Matai rocks, which contain a Permo-Carboniferous fauna.

Triassic beds appear at intervals from Kawhia on the western coast of the North Island to Nugget Point on the south-eastern coast of the South Island—a distance of 620 miles. Except in two localities, they are everywhere very steeply inclined, and where they approach the Alpine Chain of the South Island pass into semi-metamorphic greywackes or completely metamorphic phyllites and schists. They are of great thickness. A short description of the special faunal, lithic, and tectonic features of each of the more important localities is given, all of which but one occur in the South Island. In the North Island only the Noric and Rhætic horizons have been recognized. Wherever the sequence is preserved, the Trias passes conformably up into Jurassic deposits.

The lowest fossiliferous horizon of the Trias occurs near the top of a great thickness of greywackes and conglomerates called the Kaihiku Series, and is separated by several hundred feet from the next fossiliferous beds above it. The Kaihiku fossils are scanty in species, and no Cephalopods occur. Among those restricted to this horizon is *Daonella indica*, Bittner, which occurs in Ladino-Carnic deposits in the Himalayas and in the Malay Archipelago. Members or survivors of a Muschelkalk fauna occur in the form of *Spiriferinæ*

of the group of *Spiriferina fragilis*, Schlotheim. It is concluded that the Kaihiku fossil horizon is either late Middle or early Upper Trias, and the great unfossiliferous series below it represents the Middle and possibly Lower Trias.

The most highly fossiliferous division is the Carnic—the Oreti and Wairoa Series of New Zealand geologists. Several Ammonites occur, among which *Discophyllites* cf. *ebneri*, Mojsisovics, is found in the Carnic and Lower Noric of the Himalayas. The *Halobiæ* include *H. zitteli*, Lindström, a Spitsbergen fossil, together with *H. hochstetteri*, Mojsisovics, and *H. austriaca*, Mojsisovics. Several of the Carnic fossils show affinities with European Alpine forms, and can be used for purposes of correlation.

The Noric horizon, the Otapiri Series in part, is represented by felspathic sandstones containing immense quantities of *Pseudomonotis*, a genus which characterizes the Noric in all the Circum-Pacific Trias. *Ps. richmondiana*, Zittel, is known only from New Zealand and New Caledonia; but the author found the Asiatic, Siberian, and Japanese form *Ps. ochotica*, Teller, in all its varieties, in very high Noric beds near Nelson.

The Rhætic, the upper part of the Otapiri Series of local geologists, comprises a great thickness of sandy and pebbly beds. Its fossils include an extremely alate *Spiriferina* and a group of specialized bisulcate Spirigerids. An Arcestid of Rhætic aspect was collected high up in these beds at Kawhia.

Forty-seven genera and species of molluscs and Brachiopods are recorded in the present paper, of which three genera and forty-one species are regarded as new.

The Brachiopods are of considerable interest, and exhibit phylogerontic tendencies in several of the groups as they approach extinction.

The affinities of the New Zealand Trias with that of the Malay Archipelago, and especially of New Caledonia, is discussed; and it is shown that the faunal transgression which occurred over those regions, at or shortly before the commencement of Upper Triassic times, extended also to the area now occupied by New Zealand.

In the discussion which followed, the author stated that the true relationship of the Mount Torlesse Annelid Beds was still one of the unsolved problems of New Zealand geology. The question of their stratigraphy is discussed by McKay and others, and the evidence seems to show that they form the upper part of the Maitai Series. The Annelid Beds have not been traced in the Nelson district, the classical area of the Maitai Series; but he had himself found a piece of annelid-like tube in the Maitai Limestone of the Wairoa Gorge, accompanied by *Zaphrentis* and Permo-Carboniferous Brachiopods.

He did not think the Mount Torlesse Annelid Beds in any way equivalent to the Yakutat Slates of Alaska, as he had shown that the large bivalve in the Maitai Argillites overlying the Limestone near Nelson, formerly supposed to be *Inoceramus*, is apparently identical with *Aphanaia*, de Koninck, of the Permo-Carboniferous of New South Wales.

Inoceramya, Ulrich, of the Yakutat Slates, is a shell of the

Inoceramus group, and bears a row of areal ligament pits. The Lias, or at least the Lower Jurassic, is a well-defined formation in New Zealand, where it overlies the Trias, and in no way resembles the Annelid Beds.

He felt much interest in the fact that Dr. Bather had determined the scanty crinoid remains that he collected in the Kaihiku Beds as rather of Upper than of Middle Triassic age. All evidence that these deposits were Permian or Lower Trias seemed now entirely removed.

2. "The Triassic Crinoids from New Zealand collected by Mr. C. T. Trechmann." By Francis Arthur Bather, M.A., D.Sc., F.R.S., F.G.S.

The specimens are all from the Kaihiku Series, and comprise: (1) an *Entrochus* from near Nelson, with a broadly waved suture: (2) a rock-fragment from the Hokanui Hills, containing imprints of columnals and brachials representing two genera: namely, (*a*) an *Entrochus* with ridges of the joint-face arranged in pairs separated by shorter ridges; (*b*) an *Isocrinus*, of the group of *I. dubius* (Goldfuss). Comparison of the three new species based on all these remains with the Triassic crinoids described from Europe and especially with those from North America, leads to the conclusion that they are of Upper Triassic age. They bear, however, no resemblance to the Upper Triassic crinoids from Timor, which the author has in hand for description.

3. "On a Spilitic Facies of Lower Carboniferous Lava-flow in Derbyshire." By Henry Cruden Sargent, F.G.S.

The igneous rocks of Derbyshire form a basic series, consisting mainly of lavas and sills, hitherto classed as olivine-dolerites and basalts, often associated with tuffs and agglomerates. All these rocks occur in Lower Carboniferous strata. The lavas were submarine and contemporaneous.

Specimens of the lavas from certain localities exhibit a trachytic structure, and possess affinities with both spilites and mugearites. These specimens are all intensely decomposed, felspar being generally the only original mineral that is determinable. The alkali content sometimes exceeds 7 per cent, potash being always important and sometimes predominant. The felspar species are oligoclase and orthoclase, with generally a more basic plagioclase subordinate. Replacement by alkali-felspar frequently occurs.

Field evidence shows that these spilitic rocks, as a rule, underlie the basalts. A gradation may be traced between the two extremes of the series.

It is suggested that the whole series has been derived from a common magma of normal basaltic type, and that, by the upward passage of gases through the magma, a relative concentration of the alkalies took place in its upper part, which was the earliest erupted.

It is further suggested that the intense decomposition of the spilites is a case of auto-metamorphism, due to retention of volatile constituents resulting from the physical environment of a submarine flow.

An analogue to the radiolarian cherts and jaspers, generally associated with spilites in other localities, is found in Derbyshire, in the quartz-rock and other siliceous rocks that frequently occur in proximity to volcanic vents.

Since the spilites appear to be differentiates from a normal basaltic magma, resulting largely from their physical environment, it is concluded that they do not form a separate suite of igneous rocks distinct from other alkaline rocks.

ANNUAL GENERAL MEETING.

2. *February* 16, 1917.—Dr. Alfred Harker, F.R.S., President, in the Chair.

The reports of the Council and the Library Committee were read. It was stated that 34 Fellows were elected in 1916 (3 more than in 1915). During the same period, the losses by death, resignation, and removal amounted to 66, the actual decrease in the number of Fellows being 32. The total number of Fellows on December 31, 1916, was 1231.

The balance-sheet for that year showed receipts to the amount of £2,668 3*s*. 1*d*. (excluding the balance of £635 13*s*. 4*d*. brought forward from 1915) and an expenditure of £2,627 4*s*.

Reference was made to the decease of the Treasurer, Mr. Bedford McNeill, and to the election, in his place, of Dr. J. V. Elsden.

The awards of the various Medals and Proceeds of Donation Funds in the gift of the Council were enumerated in the GEOLOGICAL MAGAZINE for March, 1917, p. 140.

The Reports having been received, the President handed the Wollaston Medal, awarded to Professor Antoine François Alfred Lacroix, F.M.G.S., to Sir Archibald Geikie, O.M., for transmission to the recipient, addressing him as follows:—

Sir ARCHIBALD GEIKIE,—For a Medal instituted "to promote researches concerning the mineral structure of the Earth" it would be difficult to find a fitter recipient than Professor Lacroix, to whose labours in the domain of mineralogy and petrology our science is so deeply indebted. His researches on the optical and crystallographic constants of numerous minerals have given us a mass of useful data; but it has always been his practice to extend his investigations to the field as well as to the laboratory. His studies of the mode of occurrence, the mutual associations, and the manner of origin of a host of species have done much to rehabilitate mineralogy as, not merely a department of physics and chemistry, but a fascinating branch of natural history. His many separate papers deal with material from all parts of the world; but of chief importance will always be reckoned his four volumes on the mineralogy of France and her Colonies, a single-handed work unique in its wide scope and comprehensive treatment.

In petrology, too, Professor Lacroix's contributions have been numerous and many-sided. Of special note for their influence upon the science are his researches on contact-metamorphism, contained in bulletins of the Geological Survey of France, his various memoirs treating of the inclusions in igneous rocks, and his comparative study of the volcanic products of Mont Pelé, followed by a like examination of the rocks of Vesuvius.

From the products of volcanoes to the physics of volcanic action is a natural transition, and in respect of both Professor Lacroix's mission to Martinique in 1902 was eminently fruitful in results. In particular he was able to elucidate two remarkable phenomena previously unrecognized or unappreciated, the peculiar plugs or domes formed under certain conditions by extruded lavas and that most terrible of all volcanic effects, the *nuée ardente*.

As a diligent student of his writings, I feel a special pleasure in placing the Wollaston Medal in your hands for transmission to Professor Lacroix. With no less pleasure, I am sure, will all British geologists see his name added to a list which is already graced by the names of Élie de Beaumont and Ami Boué, Daubrée and Des Cloizeaux; and they will acclaim this award the more cordially since, in doing homage to a distinguished savant, we are honouring a citizen of a great nation, with which our own is linked, as we hope, by enduring ties.

Sir Archibald Geikie replied:—

Mr. President,—It is both a signal honour and a welcome pleasure to me to have been requested by my friend Professor Lacroix to receive this Medal on his behalf. He has asked me to express to you and to the Society his grateful thanks that you should have thought him worthy of your highest prize, and at the same time to assure you how deep is his regret that his official engagements prevent him from leaving Paris and being with us here to-day. You are aware that he has now added to his ordinary professional duties those of Secrétaire Perpétuel de l'Académie des Sciences, thus following, at no great interval of time, another eminent geologist of France, our lamented Foreign Member De Lapparent.

You have sketched with well-merited appreciation the wide range of investigation through which our latest Wollaston Medallist has pursued his studies. He has united with pre-eminent skill the detailed work of the laboratory with an appeal to the essential evidence which can only be obtained in the field. In this latter branch of research he has been fortunate in having as his companion and fellow-labourer a devoted and enthusiastic wife. Madame Lacroix, as the daughter of Ferdinand Fouqué, has inherited her father's scientific ardour, and has proved herself to be as capable and enduring a mountaineer as her husband.

Professor Lacroix has sent me a brief address to you, Mr. President, expressive of his grateful recognition of the honour which the Geological Society has conferred upon him. I have ventured to make a translation of this address, which I will now read:—

"Mr. President,—No honour could be more appreciated by me than that which the Geological Society of London has conferred upon me. Over and above the pride which I feel in this award from so many competent judges, among whom are not a few who pursue the same researches as those to which I have devoted myself, there is added, in present circumstances, the further gratification to see the ties strengthened which from old times have linked the men of science in our two countries—Britain now striving, with all her power and all her soul, hand in hand with France in defence of Right and Liberty.

"You have wished this year, I am sure, to honour in a more special manner French geology, and this adds a further reason why I should be touched that you have chosen me as the recipient of your prize.

"In being so good as to represent me at your anniversary, Sir Archibald Geikie, for whose work I have as great an admiration as I have respectful esteem for him personally, will convey to you, as far as that is possible, my regret that my official duties here prevent me from being present with you, and expressing with my own living voice all my gratitude.

"Among the distant memories of my student days there rises in my mind the recollection of my old and dear master Des Cloizeaux (the friend of your Professor Miller) carefully taking out of a drawer in his writing-table the Wollaston Medal which he had some time before received from you, and showing it to his pupils as one of the most valuable tokens of esteem that he had ever received in the course of his long and laborious career.

"How, indeed, could one not be proud, though with all humility, to see one's name inscribed in your golden book below those of the founders of our science, and following those among you who with such brilliance continue to maintain their great and glorious inheritance?

"Be so good, Mr. President, as to receive the expression of my highest consideration.

"A. Lacroix."

In handing the Murchison Medal, awarded to Dr. George Frederic Matthew, to Dr. J. E. Marr, for transmission to the recipient, the President addressed him as follows:—

Dr. Marr,—In awarding the Murchison Medal to Dr. G. F. Matthew the Council desires to mark its high appreciation of the services which he has rendered to geology, more particularly by his researches among the Lower Palæozoic rocks of New Brunswick.

Engaged for many years in official duties, and enjoying little of the advantages which come from association with fellow-workers and from access to large libraries and museums, he has still found time and means to make valuable contributions to our science. So long ago as 1865 he communicated an important paper to this Society, but most of his results have seen the light in Canadian and American journals. Of first importance must be reckoned his *Illustrations of the Fauna of the St. John Group*, published by the Royal Society of Canada, a work embodying much patient and skilful research. A paper which appeared in 1895, in the Transactions of the New York Academy of Sciences, contained the first account of the *Protolenus* fauna. Of other important contributions which Dr. Matthew has made to Lower Palæozoic geology I may mention his discoveries of the Etchiminian and the still older Coldbrook fauna beneath what had previously been considered the oldest fossiliferous horizon in New Brunswick. His work has been distinguished throughout by a happy combination of stratigraphical skill with palæontological knowledge, and some of his studies, such as those on the evolution of the Cambrian Trilobites, have had far-reaching consequences.

I have much pleasure in handing this Medal to you for transmission to the veteran Canadian geologist, and hope that he will see in it a token that his labours in the field of science are not without recognition in this country.

Dr. Marr replied:—

Mr. President,—The interval that has elapsed since the award of the Murchison Medal has been too short, in these times of stress, to allow Dr. Matthew to send an acknowledgment. Had he done so he would doubtless have expressed to the Council his gratification at the honour conferred upon him.

I am glad to receive the Medal on his behalf, so that I, an old friend, may add my appreciation of the value of his work, although this is unnecessary after the sympathetic words which you, Sir, have offered concerning it.

Dr. Matthew's name is the latest in a long list of Canadians on our roll of honour, for the men of the Dominion have excelled in the field of our science, as latterly in another and a sterner field.

I feel that I may, on behalf of the Fellows of the Society, express the wish that our Medallist, veteran though he be, may yet enjoy many years in the study of his favourite science.

The President then handed the Lyell Medal, awarded to Dr. Wheelton Hind, F.R.C.S., to Dr. A. Smith Woodward, for transmission to the recipient, addressing him as follows:—

Dr. Smith Woodward,—The Lyell Medal has been awarded by the Council to Dr. Wheelton Hind as a token that he has, in the words of its founder, "deserved well of the science."

On the side of descriptive and systematic palæontology his two memoirs on the Carboniferous Lamellibranchiata, published by the Palæontographical

Society, have long taken rank as standard works, and he has supplemented them from time to time by many other contributions dealing with the same subject. Further, he has brought his palæontological knowledge to bear upon important questions of stratigraphy, and has shown that the lamellibranch faunas of different groups of rocks furnish valuable data for purposes of comparison. In this way he has taken no small part in the correlation of the Carboniferous strata in different areas in Britain, and has further pushed his inquiries to the Continent of Europe.

The quantity, as well as the quality, of his geological work seems the more remarkable when we remember that his researches have been carried out in the intervals, none too frequent, of a busy professional life. In conferring upon him this mark of recognition, so well earned, we are thus honouring one of those amateur workers to whom British geology has always been signally indebted. In presenting it I express the hope that, when happier days bring again some allowance of leisure, Dr. Hind will be able to renew those investigations which have already proved so rich in results.

Dr. Smith Woodward replied in the following words :—

Mr. President,—I shall have much pleasure in transmitting the Lyell Medal to my friend Dr. Wheelton Hind, on whom it has been so worthily bestowed. Geological science has always been greatly indebted to the medical profession for important advances made in their brief intervals of leisure, and Dr. Hind has for many years excellently maintained the old tradition. Recognizing the importance of combining work in the field with detailed palæontological research in the study, he soon became one of the most successful exponents of the modern methods of stratigraphical geology. Beginning researches on the Carboniferous rocks in his own district of North Staffordshire, he has gradually extended his domain until, as you have well said, Sir, he has taken no small part in the correlation of the Carboniferous strata of Britain. As soon as he is released from the military duties which prevent his attendance at the meeting to-day, I feel sure that Dr. Hind will return with renewed vigour to the geological work which has so long been his recreation ; and he desires me to express his best thanks to the Council of the Geological Society for the stimulating award with which they have honoured him.

In handing the Bigsby Medal, awarded to Mr. Robert George Carruthers, to Dr. A. Strahan, Director of H.M. Geological Survey, for transmission to the recipient, the President addressed him as follows :—

Dr. Strahan,—The Bigsby Medal has been awarded to Mr. Carruthers by the Council as an acknowledgment of his eminent services to Scottish geology. As an officer of the Geological Survey he has investigated considerable areas of the ancient rocks of the Highlands, the Carboniferous of the Scottish Midlands, and the Old Red Sandstone of Caithness ; and in each of these fields his labours have yielded results which possess more than a local interest. On the side of pure palæontology he has made important additions to our knowledge of the Corals, in particular by his memoir dealing with the morphology of the Rugosa ; but especially are geologists indebted to him for the use which he has made of the Corals in the zonal subdivision of the Carboniferous succession. Of other palæontological contributions having a direct stratigraphical application, I will recall only his discovery of a Pendleside fauna in the Calciferous Sandstone Series of Lanarkshire and his reference of the fish-fauna of Achanarras to its true position in the Old Red Sandstone sequence. Among his services to economic geology his revision of the memoir on the oil-shale fields of the Lothians is especially worthy of mention.

The founder of this Medal, in fixing an age limit for the recipient, made clear his intention that regard should be had, not only to performance in

the past, but to promise for the future. Confident that in this case the one is a sure guarantee of the other, we ask him to receive this award in the double acceptation of a tribute and an encouragement.

Dr. Strahan replied :—

Mr. President,—It is a great pleasure to me to receive, on behalf of my colleague on the Geological Survey, this testimony of the value that the Council attaches to his work. You have referred in generous terms to Mr. Carruthers's contributions to our knowledge of Scottish geology, and to his researches in pure palæontology. His application of scientific methods of investigation to corals has done much to elucidate stages of evolution in those lowly organisms, and I believe that your recognition of this branch of his work will be especially gratifying to him. In economic geology the demands made upon the staff by the exigencies of war were sudden and imperative, and no one knows better than myself how well Mr. Carruthers and his colleagues responded to the call, and for the time resisted the fascinations of abstract science.

Mr. Carruthers, writing amid the distractions of the Western Front, tells me that it is

"almost impossible to give any adequate expression of my gratitude to the Society for their award of the Medal. . . . As the bulk of my work has been concerned with economic geology, the honour of this award is shared equally with my comrades on the Survey. . . . In the field of abstract science my ventures have been little more than tentative. I hope that the generous encouragement that they have always received from the Society may ultimately be repaid in some degree. The obligation is, of course, greatly increased by this additional proof of trust".

May I express the hope, for myself and for the Fellows of the Society, that it will not be long before Mr. Carruthers can resume his scientific work and justify the confidence that you have so gracefully expressed in his promise for the future?

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Percy George Hamnall Boswell, D.Sc., the President said :—

Dr. Boswell,—The Balance of the Proceeds of the Wollaston Donation Fund has been awarded to you by the Council in recognition of your work in East Anglia, by which you have added to our knowledge of the subterranean as well as the superficial geology of that area. In your earlier contributions you examined the origin of the existing river-system of Suffolk, and also endeavoured to define the limits of extension of the Lower Glacial deposits of Norfolk into the more southerly county. You have also made instructive researches into the lithology and mineralogy of many of the sedimentary deposits of East Anglia. In a paper read before this Society two years ago you employed this method, in conjunction with stratigraphical observation, in a comprehensive study of the Lower Eocene strata of the area, and drew interesting conclusions concerning the geography of the period and even the tectonics of the country. Your more recent investigations concerning sands suitable for glass-making have a direct practical application of much importance at the present time.

Some part of your work has been the outcome of a grant from the Daniel Pidgeon Fund, and the good use which you made of that opportunity assures us that you will regard the present award as an incentive to new enterprises in the service of Geology.

The President then handed the Balance of the Proceeds of the Murchison Geological Fund, awarded to Dr. William Mackie, to Dr. W. T. Gordon, for transmission to the recipient, said :—

Dr. Gordon,—The Balance of the Proceeds of the Murchison Geological Fund has been awarded by the Council to Dr. Mackie in recognition of his

contributions to the geology of Northern Scotland. A skilled chemist as well as a keen petrologist, he has utilized in this way his leisure as a medical practitioner during the last twenty years.

By his investigation of the sandstones of Eastern Moray he has thrown light, both on the source of the material and on the climatic conditions which prevailed during its deposition. In the cement of these sandstones he detected traces of the heavy metals, and his inquiry led to the discovery in quantity of barytes and fluor in the Elgin Trias. His petrographical work includes an interesting study of the granites of the North of Scotland, and he has also carried out a large series of chemical analyses of igneous and sedimentary rocks in order to elucidate theoretical questions suggested in the course of his researches.

His recent discovery of plant-bearing cherts in the Old Red Sandstone of Rhynie (Aberdeenshire), has added a new interest to that formation. Dr. Kidston and Professor Lang recognize these cherts as silicified layers of peat, and a new class of vascular Cryptogams, the Psilophytales, has been made for the reception of the plants which they contain.

I ask you, in forwarding this award to Dr. Mackie, to convey to him our hope that he will thereby be encouraged to continue the researches which he has hitherto pursued with such enthusiasm.

The President then presented a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Arthur Hubert Cox, Ph.D., said :—

Dr. Cox,—The Council has awarded to you one moiety of the Proceeds of the Lyell Fund in recognition of the value of your work among the Lower Palæozoic rocks. Since you read before this Society, five years ago, a paper on the Pedwardine Inlier, you have devoted much time to geological researches in Wales, both South and North. Your paper on the Abereiddy and Abercastle district was a valuable contribution to the stratigraphy and tectonics of Pembrokeshire, and gave evidence of skilful and accurate work in the field. On the petrological side, too, it added to our knowledge of the Ordovician igneous rocks, a subject to which you have also given attention elsewhere. Your work in the Cader Idris district, of which we have as yet only a preliminary account, seems to be of the same thorough quality ; and, in thus marking our appreciation of what you have already done, we look forward to results not less important from your geological labours in the time to come.

In handing the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Tressilian Charles Nicholas, M.A., to Mr. H. Woods, for transmission to the recipient, the President said :—

Mr. Woods,—A moiety of the Proceeds of the Lyell Fund has been awarded to Mr. T. C. Nicholas as a mark of appreciation of his work on the older Palæozoic rocks of Carnarvonshire. The results of that work are represented firstly by a paper on the Geology of the St. Tudwal's Peninsula, in Lleyn, read before this Society in 1914. Therein he gave a comprehensive account of the succession, fossil contents, and classification of the Cambrian strata of the district, and established the unconformity which exists between these beds and the overlying Ordovician. This paper was supplemented in the same year by a palæontological one dealing with the rich trilobitic fauna, of Middle Cambrian age, which his researches had discovered. A number of new and interesting species were described, and the succession of forms was correlated with that recorded for other areas.

As an old friend of Mr. Nicholas, and one who has seen something of the difficulties presented by the Lleyn district, I am pleased that it falls to my lot to extend to him, on behalf of the Council, this token of recognition of his geological and palæontological work.

The President then presented the Balance of the Proceeds of the Barlow-Jameson Fund to Mr. Henry Dewey, said:—

Mr. DEWEY,—The Proceeds of the Barlow-Jameson Fund have been awarded to you in recognition of your services to Geology and as an encouragement to you for the future. In the record of your geological work the first place belongs to your researches in North Cornwall, where you were engaged as an officer of the Geological Survey. There your mapping led you to recognize a number of subdivisions of the Devonian strata and to determine their natural sequence, and with this help you were able to demonstrate the existence of important overthrusts in that area. The peculiar features of the 'pillow-lavas' intercalated in the Upper Devonian also engaged your attention, and your paper on the 'spilitic series', written in collaboration with Dr. Flett, has proved a valuable contribution to petrology. Of not less consequence, of another kind, were your paper on the Raised Beach of North Devon and that which you read before this Society a year ago on the Origin of River-gorges in Cornwall and Devon. Your removal from the West of England to the Thames Valley introduced you to new problems, to which you have brought the same zeal and insight, and it is our hope that you will find in the present award an incentive to further investigations in the field of Geology.

The President proceeded to read his Anniversary Address, including first obituary notices of Jules Gosselet (elected Foreign Member in 1885), J. W. Judd (el. Fellow 1865), J. H. Collins (el. 1869), C. T. Clough (el. 1875), Clement Reid (el. 1875), Bedford McNeill (el. 1888), H. Rosales (el. 1877), W. E. Koch (el. 1869), C. Dawson (el. 1885), T. de Courcy Meade (el. 1891), and others.

The remainder of the Address dealt with some aspects of igneous action in Britain, and especially its relation to crustal stress and displacement. This relation appears not only in the distribution of igneous activity in time and space, in the succession of episodes, the habits of intrusions, etc., but also in the petrographical facies of the igneous rocks themselves. The cause of such relation was sought in the existence of extensive inter-crustal regions in a partially molten state: that is, with some interstitial fluid magma, which must normally be rich in alkaline silicates. There will be a continual displacement of the interstitial magma from places of greater stress to places of less stress, and certain broad differences in chemical composition are therefore to be expected between the igneous rocks of orogenic belts and those erupted in connexion with gentle subsidence.

The Archæan plutonic rocks were intruded in close relation with powerful lateral thrust, and they accordingly include no alkaline types; but the Dalradian sediments were deposited in an area of tranquil subsidence, and the lavas intercalated in them are of the spilitic kind, rich in sodic felspars.

The Lower Palæozoic formations were laid down in a geosyncline, which for a long time experienced merely a slow depression, and the late Cambrian and early Ordovician eruptions, situated chiefly along the borders of the area, had a pronounced sodic facies. In mid-Ordovician times there entered a certain element of lateral thrust, and accordingly in the Llandeilian vulcanicity the spilitic type gave place to the andesitic; but the scattered outbreaks of Bala and Silurian age often afford evidence of a reversion to the earlier facies.

Following upon the great Caledonian crust-movements there was, in the Scottish Highlands and elsewhere, a copious intrusion of plutonic magmas, all of "calcic" as contrasted with alkaline types. The same characteristic belongs to the igneous rocks of the Lower Old Red Sandstone, which were extruded and intruded in connexion with the later Caledonian folding, while the country was still in a condition of stress. With the dying out of this stress a more alkaline facies supervened, and the Lower Carboniferous igneous rocks of Scotland, though developed largely in the same synclinal folds as the preceding series, present a strong contrast in petrographical characters. They indicate a certain richness in soda, and this feature becomes more pronounced, until it culminates in the Permian of Ayrshire and East Fife in highly alkaline rock-types.

In Southern England, remote from the main Caledonian disturbance, the Devonian and Carboniferous lavas are of the same spilitic type as those of the early Ordovician. Later, this part of the British area was involved in the Hercynian crust-movements, which were accompanied by the intrusion of the Cornish granites and their satellites.

In Mesozoic times our country experienced no orogenic disturbance of a pronounced type, and there was a prolonged cessation of igneous activity. The Tertiary Era introduced a new factor in the form of very extensive plateau-faulting, bearing no relation to the structure of the country. This movement, generally of the nature of subsidence, affected a vast area, of which Northern Britain is only a small fraction, and was attended by igneous action on the same extensive scale. The mechanism of extrusion and intrusion differed in important features from that illustrated by the Palæozoic eruptions. The Tertiary igneous rocks, as a whole, are decidedly, though not strikingly, rich in soda; but this alkaline character is lost in the neighbourhood of isolated centres, where there is evidence of locally developed stresses of an acute type.

The ballot for the Officers and Council was taken, and the following were declared duly elected for the ensuing year :—

Officers: *President*, Alfred Harker, M.A., LL.D., F.R.S. *Vice-Presidents*, R. Mountford Deeley, M. Inst. C. E.; Edwin Tulley Newton, F.R.S.; Professor William Johnson Sollas, M.A., LL.D., Sc.D., F.R.S.; and Arthur Smith Woodward, LL.D., F.R.S., F.L.S. *Secretaries*, Herbert Henry Thomas, M.A., Sc.D.; and Herbert Lapworth, D.Sc., M. Inst. C. E. *Foreign Secretary*, Sir Archibald Geikie, O.M., K.C.B., D.C.L., LL.D., Sc.D., F.R.S. *Treasurer*, James Vincent Elsden, D.Sc.

Other Members of Council: Charles William Andrews, D.Sc., F.R.S.; Professor John Cadman, C.M.G., D.Sc., M. Inst. C. E.; Professor Charles Gilbert Cullis, D.Sc.; Arthur Morley Davies, D.Sc., A.R.C.Sc.; Professor Edmund Johnston Garwood, M.A., Sc.D., F.R.S.; Walcot Gibson, D.Sc.; Finlay Lorimer Kitchin, M.A., Ph.D.; George William Lamplugh, F.R.S.; John Edward Marr, M.A., Sc.D., F.R.S.; Richard Dixon Oldham, F.R.S.; Robert Heron Rastall, M.A.; Professor Thomas Franklin Sibly, D.Sc.; Sir Jethro J. Harris Teall, M.A., D.Sc., LL.D., F.R.S.; and Samuel Hazzledine Warren.